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ABSTRACT

These teacher's materials for a seven-unit course were developed to help students develop technological literacy, career exploration, and problem-solving skills relative to the communication industries. The seven units include an overview of energy and power, principles of energy and power, power production and conversion, power transmission and storage, transportation systems, transportation technical subsystems, and future projections. The first section is designed to teach teachers how to use the materials and includes an explanation of instructional elements, an instructional-task analysis for each unit, and a list of 24 references. The instructional elements for the units include objectives, suggested activities, information sheets, transparency masters, assignment sheets, job sheets, tests, and test answers. Some elements, such as the information sheets, include photographs, diagrams, and line drawings. (CML)

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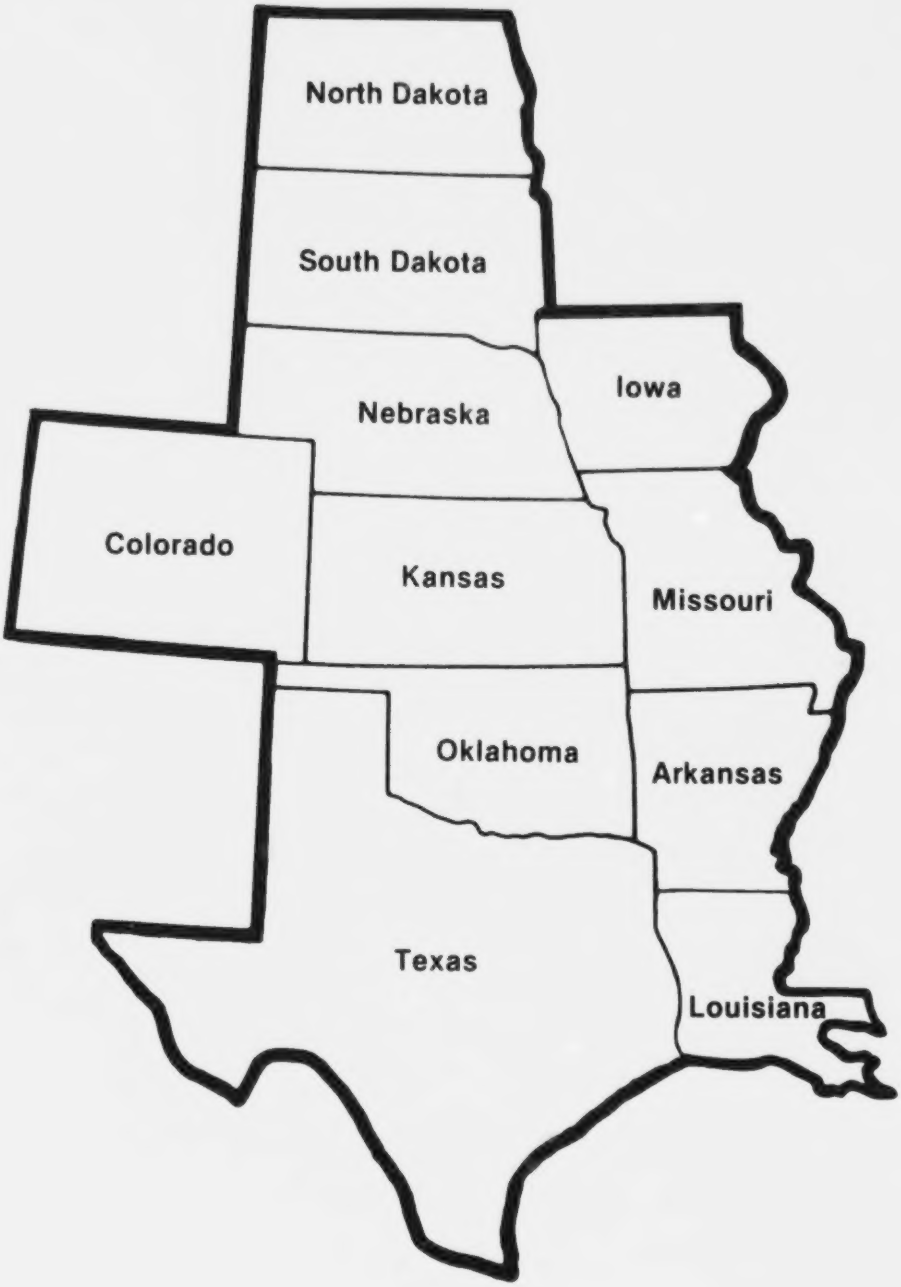
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EXPLORING ENERGY, POWER, AND TRANSPORTATION TECHNOLOGY

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EXPLORING ENERGY, POWER, AND TRANSPORTATION TECHNOLOGY

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FOREWORD

Technology education/industrial arts instructors are being asked to make radical changes in their programs to reflect the radical changes in our technological society. Rapid change and the current clamor for educational reform have made it evident that improvements must be made to meet the needs of students who will compete in a world quite different from the one they are experiencing in the classrooms and laboratories.

We are at the point where we need to overhaul traditional industrial arts programs and bring new and emerging technologies into the curriculum. However, the lack of instructional materials to support this new curriculum effort has made it extremely difficult. Hopefully, the new **MAVCC Technology Education Series** will aid teachers in updating and revitalizing their programs.

The series begins with *Exploring Technology Education,* Level I, which is followed by four Level II books which individually explore the technology systems of communication, construction, manufacturing, and energy, power, and transportation.

The book you are holding, *Exploring Energy, Power, and Transportation Technology,* is one of the Level II publications in this series. It has been developed to give students technological literacy, career exploration, and problem-solving skills dealing with the energy, power, and transportation industries.

Every effort has been made to make this publication basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from the publication: motivation, personalization, and localization. These areas are left to the individual instructors who should capitalize on them. Only then will these publications become a vital part of the teaching-learning process.

Harley Schlichting, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

Greg Pierce
Executive Director
Mid-America Vocational
Curriculum Consortium

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The contents of this publication were planned and reviewed by the following members of the Mid-America Vocational Curriculum Consortium technology education committee:

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Special appreciation is extended to **Dr. Kendall Starkweather** of Reston, Virginia for representing the International Technology Education Association (ITEA) on this committee.

Gratitude is expressed to the employees of the Graphics Division of the Oklahoma State Department of Vocational-Technical Education for their assistance with the phototypesetting, artwork, pasteup, and printing of this text.

Thanks are also extended to **Mary Kellum,** MAVCC Publication Specialist, for her assistance with the editing of this book, as well as the coordination of the entire project.

USE OF THIS PUBLICATION

Instructional Units

Exploring Energy, Power, and Transportation Technology contains seven units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction; performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated

    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations

C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities for the Instructor

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. Duties of instructors will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledge which is a necessary prerequisite to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

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Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

EXPLORING ENERGY, POWER, AND TRANSPORTATION TECHNOLOGY

INSTRUCTIONAL TASK ANALYSIS

PRACTICAL APPLICATION: What The Student Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)
UNIT I: OVERVIEW OF ENERGY AND POWER	
	1. Terms and definitions
	2. Forms of energy
	3. Classifications of energy sources
	4. Early uses of energy
	5. Present day uses of energy
	6. Early sources of power
	7. Simple machines
	8. Complex machines
	9. Conservation of resources
	10. Reading a gas or electric meter
11. Read sample meters	
12. Read home meter	
13. Perform an energy audit	

PRACTICAL APPLICATION: What The Student Should Be Able To Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)

UNIT II: PRINCIPLES OF ENERGY AND POWER

PRACTICAL APPLICATION: What The Student Should Be Able To Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)
	1. Terms and definitions
	2. Types of power systems
	3. Stages of power systems
	4. Basic measuring systems
	5. Basic units of measurement
	6. Prefixes for changing metric base units
	7. Units for measuring energy and power
	8. Terms and definitions related to measuring mechanical power
	9. Terms and definitions related to measuring electrical power
	10. Ohm's law in letter formula
	11. Ohm's law in triangle expression
12. Calculate problems using the formula for work	
13. Calculate problems using the formula for horsepower	
14. Calculate problems using the formula for torque	
15. Solve problems using Ohm's law	
16. Build and test a simple, low pressure steam turbine	
17. Construct a wind rotor	
18. Build an electric generator	

PRACTICAL APPLICATION: What The Student Should Be Able To Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)
UNIT III: POWER PRODUCTION AND CONVERSION	
	1. Terms and definitions
	2. Types of conversions
	3. Common direct conversion systems
	4. Common methods of converting energy
	5. Conversion of electrical power
	6. Classifications of engines
	7. Types of external combustion engines
	8. Types of internal combustion engines
	9. Operations of two-stroke and four-stroke cycle gasoline engines
	10. Parts of a basic internal combustion engine
	11. Systems of an engine and their functions and parts
	12. Safety rules to follow when working with engines
13. Check engine components for wear	
14. Disassemble and reassemble a four cycle, one cylinder engine	
15. Construct a solor battery	

PRACTICAL APPLICATION: What
The Student Should Be Able To Do
(Psychomotor)

RELATED INFORMATION: What
the Student Should Know
(Cognitive)

UNIT IV: POWER TRANSMISSION AND STORAGE

1. Terms and definitions
2. Types of power systems
3. Devices for control and transmission of mechanical power
4. Transmission of electrical power
5. Devices for control of electrical power
6. Principles of hydraulics
7. Parts of a hydraulic system
8. Steps in the operation of hydraulics
9. Applications of hydraulic transmissions
10. Advantages of hydraulic systems
11. Connectors used in fluid power systems
12. Laws defining the principles of pneumatics
13. Parts of a pneumatic system
14. Applications of pneumatics
15. Terms and definitions related to robotics
16. Major catagories of jobs in industry that are well suited for robots
17. Principles of lasers
18. Classes of lasers

PRACTICAL APPLICATION: What The Student Should Be Able To Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)
	19. Applications of lasers
	20. Types of energy and their storage devices
21. Determine gear rotation	
22. Design and build a robotic arm	
23. Build a "big track" robot	
24. Build a lemon battery	

UNIT V: TRANSPORTATION SYSTEMS

1. Terms and definitions
2. Basic modes of transportation
3. Types of intermodal transportation
4. Types of on-site transportation
5. Highway transportation
6. Rail transportation
7. Types of railway vehicles
8. Types of commercial airlines
9. Basic types of airplanes
10. Parts of an airplane
11. Space transportation
12. U.S. space projects
13. Characteristics of the space shuttle
14. Basic vessels for water transportation
15. Basic parts of a ship
16. Uses of computers for transportation systems

PRACTICAL APPLICATION: What The Student Should Be Able To Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)
17. Select modes of transportation for given situations	
18. Set up and operate a pipeline simulation	

UNIT VI: TRANSPORTATION TECHNICAL SUBSYSTEMS

PRACTICAL APPLICATION	RELATED INFORMATION
	1. Terms and definitions
	2. Types of transportation technical subsystems
	3. Elements of propulsion
	4. Types of suspension systems
	5. Types of control systems
	6. Guidance systems
	7. Structural systems
	8. Support systems
9. Identify technical subsystems	
10. Design a model racer	
11. Build a model racer	

UNIT VII: FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT

PRACTICAL APPLICATION	RELATED INFORMATION
	1. Terms and definitions
	2. Types of pollution
	3. Pollution from fossil fuels
	4. Other energy sources and their pollutions and environmental impacts
	5. Ways to control pollution
	6. Energy conservation measures

PRACTICAL APPLICATION: What The Student Should Be Able To Do (Psychomotor)	RELATED INFORMATION: What the Student Should Know (Cognitive)
	7. Emerging transmission systems
	8. Advances in transportation
9. Research trends in energy usage	
10. Write a scenario of energy use in the 2500	
11. Discuss the effect of a total absence of fossil fuels	
12. Construct a model maglev train	

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OVERVIEW OF ENERGY AND POWER
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify simple and complex machines, read meters, and perform an energy audit. Competencies will be demonstrated by correctly performing the procedures in the assignment and job sheets and by scoring a minimum of 85 percent on the written test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to energy and power with the correct definitions.
2. Match forms of energy with the correct descriptions.
3. Select true statements concerning the classifications of energy sources.
4. Discuss early uses of energy.
5. List present day uses of energy.
6. List three early sources of power.
7. Identify simple machines.
8. Identify complex machines.
9. Discuss conservation of resources within the technology systems.
10. Complete statements concerning reading a gas or electric meter.
11. Read sample meters. (Assignment Sheet #1)

OBJECTIVE SHEET

12. Read home meter. (Assignment Sheet #2)
13. Demonstrate the ability to perform an energy audit. (Job Sheet #1)

OVERVIEW OF ENERGY AND POWER
UNIT I

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheet.

H. Discuss and demonstrate the procedure outlined in the job sheet.

I. Integrate the following activities throughout the teaching of this unit:

1. Use films listed on the following page to reinforce conservation.
2. Have students build simple solar projects. Possible resources for project ideas are included on the following pages.
3. Invite professionals from local utility companies to discuss careers and energy use.
4. Visit local facilities for generating electricity and local use of alternative energies.
5. Demonstrate the simple machines shown in the Information Sheet, Section VII.
6. Make a display board of complex machines used today.
7. Discuss energy needs from a historical perspective.
8. Contact local power companies for slides and/or other audio-visual materials dealing with sources of energy and power for your area as well as new and alternative energy sources.
9. Obtain and show pictures of heat losses from public service companies. Discuss ways to prevent or lessen heat loss.

REFERENCES USED IN DEVELOPING THIS UNIT

10. Discuss R-values of different materials such as glass, concrete, and wood, and compare their values.

11. Discuss differences in energy loss between insulated and uninsulated glass, doors, and walls.

12. Conduct a survey of the school to determine the amount of electricity used (in kilowatt hours). Check for wattage of lights, number of lights and hours used daily, and price per kilowatt hour; then calculate the amount of money spent on lighting the building and then for total electricity.

13. Discuss the advantages and disadvantages of the different energy sources. Discuss both environmental issues and economic issues.

14. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

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F. Heiner, Carl W. and Wayne R. Hendrix. *People Create Technology.* Worchester, Massachusetts: Davis Publications, Inc., 1980.

SUGGESTED SUPPLEMENTAL RESOURCES

A. Films:

1. *Energy: Critical Choices Ahead* (27 min. color)
   Free Loan — Texas Power and Light, Public Service Dept.
   P.O. Box 226331, Dallas, TX 75266

SUGGESTED SUPPLEMENTAL RESOURCES

2. *Energy: The American Experience* (28 min. color) #0507
   Free Loan — ERDA Film Library, Technical Education Center
   P.O. Box 62, Oak Ridge, TN 37830

3. *Energy: New Sources* (20 min. color)
   University of Illinois, Visual Aids Service
   1325 South Oak Street, Champaign, IL 61820

4. *A Question of Balance* (28 min. color)
   Free Loan — Modern Talking Pictures
   1212 Avenue of the Americas, New York, NY 10036

B. Books and pamphlets

1. *Catch a Sunbeam: A Book of Solar Study and Experiments*, by F. Adams. 77 pp, Grades 7+. Published in 1979 by Harcourt Brace Jovanovitch, Inc., New York, NY 10017.

2. *Energy From the Sun: 33 Easy Solar Projects* by I.R. Holstroemn. 182 pp, Grades 9+. Published in 1981 by Tab Books, Inc., Blue Ridge Summit, PA 17214.

3. *Energy: New Shapes, New Careers*, by R. Millard et al. 192 pp, Grades 6+. Published in 1982 by Julian Messner, New York, NY 10020.

4. *Harnessing the Sun: The Story of Solar Energy*, by D.C. Knight. 128 pp, Grades 6-9. Published in 1976 by William Morrow & Company, New York, NY 10016.

5. *Solar Energy*, by W. Cross. 100 pp, Grades 5+. Published in 1984 by Children's Press, Chicago, IL 60607.

6. *Sun Power: Facts About Solar Energy*, by S. Gadler and W. Adamson. 130 pp, (library binding). Grades 6+. Published in 1978 by Lerner Publications, Minneapolis, MN 55401.

7. *33 Photovoltaic Projects*, by H.L. Davidson. 263 pp, Grades 9+. Published in 1982 by Tab Books, Inc., Blue Ridge Summit, PA 17214.

OVERVIEW OF ENERGY AND POWER
UNIT I

INFORMATION SHEET

I. **Terms and definitions**

A. Effort — Force applied *to* the machine

B. Energy — The ability to do work, or the capacity to produce motion, heat, or light

C. Four-stroke cycle engine — An engine that requires four strokes of the piston to produce a single power stroke

(NOTE: The four strokes are intake, compression, power, and exhaust.)

D. Mechanical advantage (MA) — The increase in force that you gain from using a machine

$$MA = \frac{\text{Resistance}}{\text{Effort}}$$

E. Power — Energy or work per unit of time, or work accomplished in a given period of time

F. Radiant energy — A form of energy traveling as wave motion, such as rays from the sun

(NOTE: Radiant energy is a combination of heat and light energy. Radiant energy changes to heat when it strikes a solid object.)

G. Resistance — Force overcome *by* the machine

H. R-value — A rating given a material's resistance to passage of heat

(NOTE: A material with a high R-value is a good thermal insulator and is energy efficient.)

I. Turbine — Rotating device driven by wind or water that is used to provide power

J. Two-stroke cycle engine — A heat engine that requires two piston strokes to produce a single power stroke

(NOTE: The two strokes are compression and power.)

II. **Forms of energy** (Transparency 1)

A. Mechanical energy — The energy of motion

(NOTE: This is the most visible and common form of energy.)

INFORMATION SHEET

- B. Heat (thermal) energy — The motion of molecules

  (NOTE: Heat is present whenever there is motion.)
- C. Light energy — The visible part of radiant energy
- D. Chemical energy — Energy produced by chemical changes

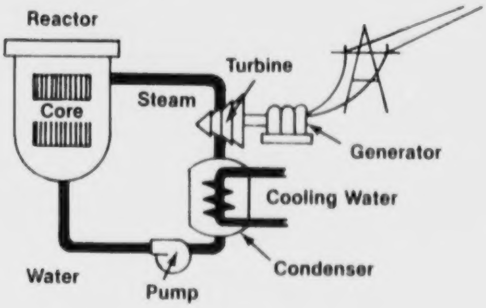
  (NOTE: It is the source of energy for all living things.)
- E. Electrical energy — The motion of electrons
- F. Nuclear energy — Energy produced by reactions in the nuclei of atoms

III. **Classifications of energy sources** (Transparency 2)

- A. Nonrenewable — Energy sources that cannot be replaced once they are used
  - 1. Fossil fuels (hydrocarbons)
    - a. These are fuels that are derived from fossilized living things deposited *millions* of years ago.
    - b. Examples include natural gas, coal, and oil.
      - 1) Natural gas (ethane, propane, butane, and methane) is used for heating, cooling, cooking, and generating electricity. It is the cleanest fossil fuel.
      - 2) Coal can be burned for heating and as fuel for electrical power plants.
      - 3) Oil is primarily used for transportation fuels (gasoline, diesel) and for heating and generating electricity.
  - 2. Uranium
    - a. Tremendous amounts of energy are released when the nucleus of uranium atoms are split.

INFORMATION SHEET

b. This energy is used in nuclear power plants to generate electricity for consumer use.



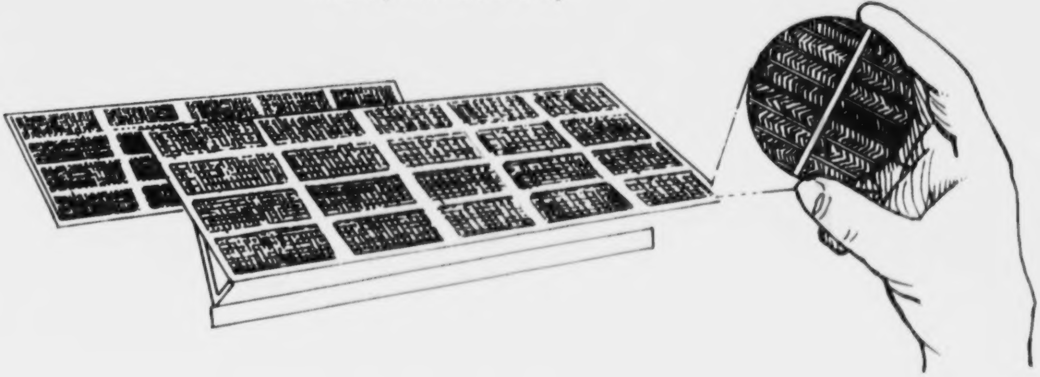
B. Renewable — Energy sources that can be used indefinitely if they are properly managed and maintained.

(NOTE: Most of the following energy sources are also referred to as alternative energies. They are being studied and developed as supplements and possible replacements for conventional energies such as fossil fuels. Although many applications have been developed, most are still not economically feasible for large scale use in all areas.)

1. Sun

   a. Used in passive and active solar applications to heat homes and businesses and for natural sunlight.

   b. Photovoltaic cells (solar cells) absorb sunlight and turn it *directly* into electricity.



Photovoltaic Modules

A Single-Crystal Silicon Solar Cell

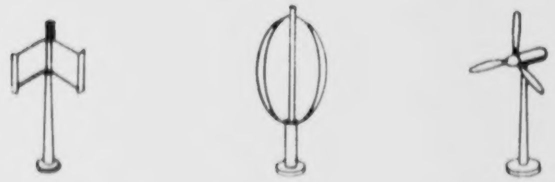
2. Wind

   a. Used naturally for sailing and drying and in windmills to mechanically grind grain and pump water.

INFORMATION SHEET

b. Presently being used in areas with steady winds to generate electricity through modern wind machines.

Types of Wind Machines

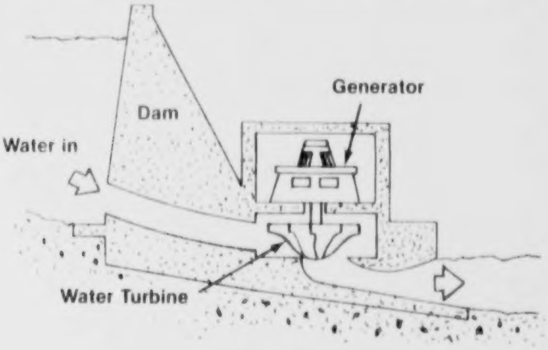


Vertical Axis   Vertical Axis   Horizontal Axis

3. Water (Hydro) — Primarily used to generate electricity. There are several forms of hydro energy.

   a. Hydroelectric power — The force of falling or flowing water in a river or stream is directed through a turbine, causing the turbine to spin. That rotates a generator which produces electricity. Often a dam is built across the river to build up the water supply and enable the power plant to generate even more electricity.

   (NOTE: Hydroelectric power plants are very common in the U.S. and generate 1/5 of all electricity produced here.)



   b. Ocean tides — The differences between high tide and low tide can be used to turn turbines and generate electricity in limited areas.

   (NOTE: Ocean wave power caused by wind driving the water to the shore is also a possible source of energy in the future.)

INFORMATION SHEET

4. Geothermal

   a. Heat generated by natural processes beneath the earth's surface can be used for heat and for generating electric power.

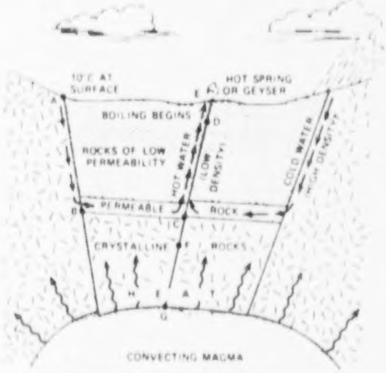

10°C AT SURFACE
HOT SPRING OR GEYSER
A
E
BOILING BEGINS
D
ROCKS OF LOW PERMEABILITY
HOT WATER
(LOW DENSITY)
COLD WATER
(HIGH DENSITY)
B
PERMEABLE
ROCK
C
CRYSTALLINE
F
ROCKS
H E A T
G
CONVECTING MAGMA

Diagram of a Geothermal Reservoir

   b. Natural examples of geothermal energy are volcanoes, hot springs, and geysers such as "Old Faithful" in Yellowstone National Park.

   c. The largest commercial geothermal electric power plant complex is The Geysers in northern California. Other plants are currently in operation or under development in the western U.S. where geothermal reservoirs are found close to the earth's surface.

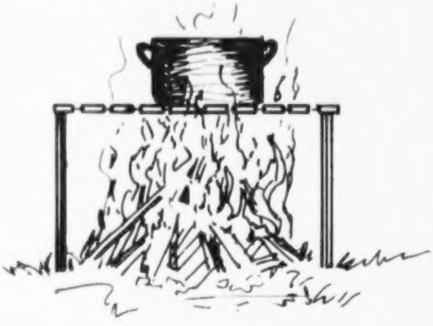
5. Plants and waste products (biomass conversion)

   a. Trees, plants, farm crops, manure, seaweed, algae, sewage, and garbage can all be used as sources of energy.

   b. These products can be burned and used as direct heat (trees) or converted into fuels such as alcohol, oil, and methane (waste products and trash) which can be used for transportation or to generate electricity.

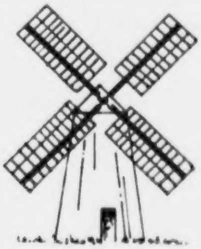
IV. Early uses of energy

A. Fire — Used for heating, cooking, and tool making

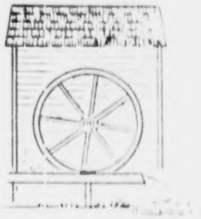


INFORMATION SHEET

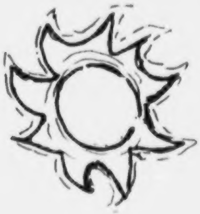
B. Wind — Used for sailing and windmills



C. Water — Used in water wheels and turbines to grind grain and irrigate crops



D. Sun — Used for light and heat



V. **Present day uses of energy** (Transparency 3)

A. Residential and commercial

1. Lighting
2. Heating and cooling
3. Cooking
4. Operating appliances and equipment

B. Industrial

1. Mining
2. Processing

INFORMATION SHEET

3. Manufacturing materials into products
4. Generating electricity

C. Transportation — For fuel and movement

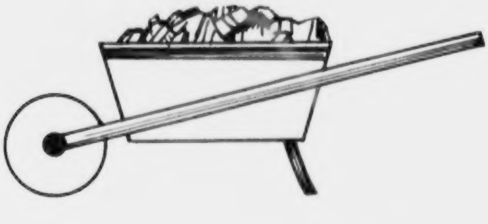
VI. Early sources of power

A. Humans — Depended upon their own muscles to hunt for food, provide shelter, and protect themselves from their enemies

B. Animals — Some species could be tamed to provide another source of power to perform work

Examples: Oxen, horses, dogs

C. Simple machines — The earliest devices that enabled humans to do work that was difficult or impossible with muscle power alone



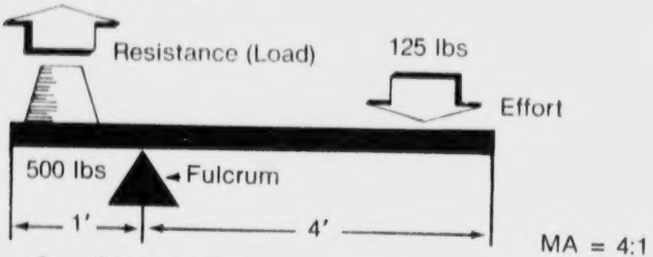
INFORMATION SHEET

VII. Simple machines

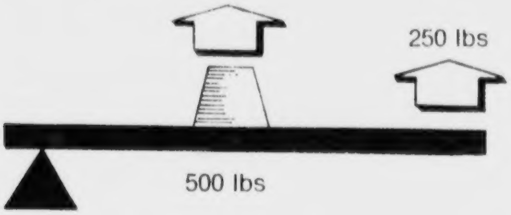
(NOTE: The use of machines gives *mechanical advantage* over doing the task without the machine.)

A. Lever — Bar resting on a pivot point or fulcrum

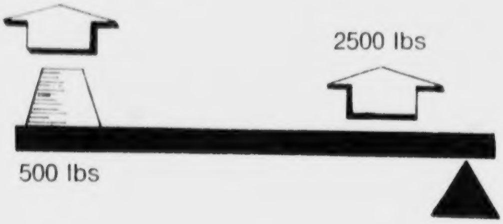
1. First class


Resistance (Load)
125 lbs
Effort
500 lbs
Fulcrum
1′
4′
MA = 4:1

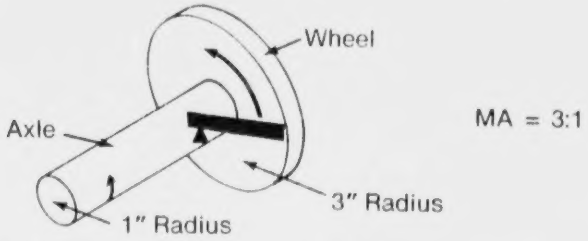
2. Second class


250 lbs
500 lbs

3. Third class


2500 lbs
500 lbs

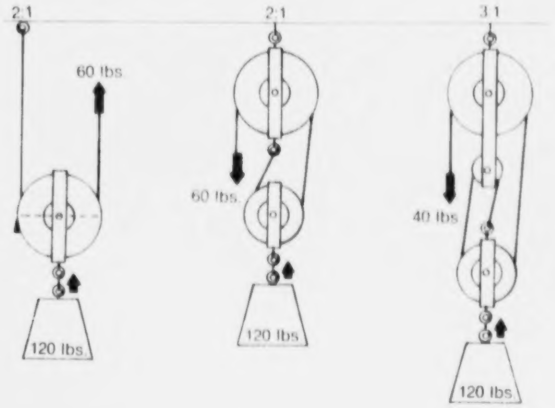
B. Wheel and axle — Operates on the same principle as the lever: radius of the wheel acts as the lever, the center of the axle is the fulcrum.


Wheel
Axle
MA = 3:1
3″ Radius
1″ Radius

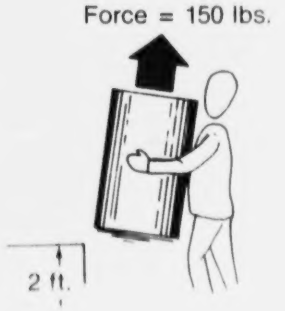
(NOTE: The mechanical advantage of the wheel and axle is the ratio between the two lever arms. The mechanical advantage shown in the figure above is 3 to 1.)

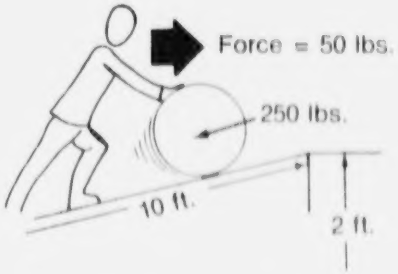
INFORMATION SHEET

C. Pulley — A wheel that turns on an axis

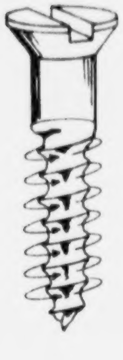

2:1
60 lbs
120 lbs
2:1
60 lbs.
120 lbs
3:1
40 lbs
120 lbs

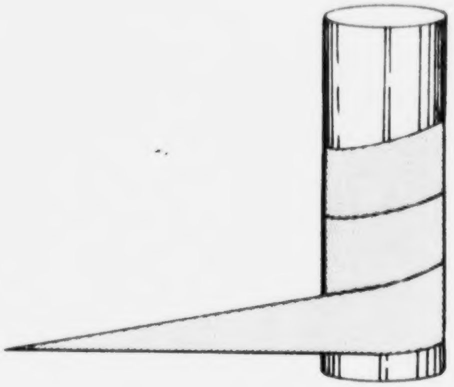
D. Inclined plane — Tapered surface along which somethings moves


Force = 150 lbs.
2 ft.


Force = 50 lbs.
250 lbs.
10 ft.
2 ft.

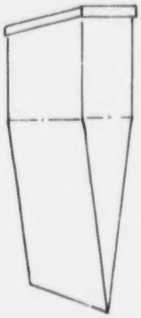
E. Screw — Spiral-shaped inclined plane wrapped around a rod



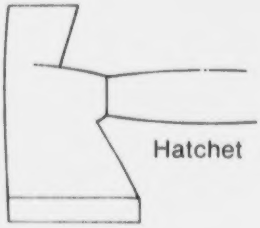


INFORMATION SHEET

F. Wedge — Made up of two inclined planes placed so that the sloping sides come together at a point



Splitting Wedge



Hatchet

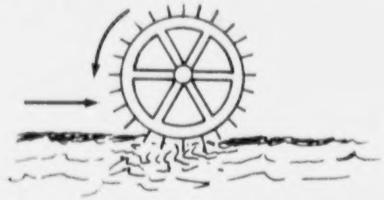
Nail

VIII. **Complex machines**

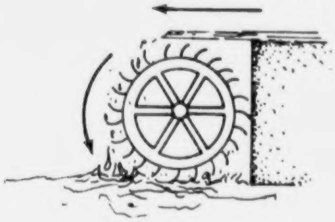
(NOTE: All complex machines use the principles of the simple machines singularly or in various combinations. The use of these machines helped bring about the Industrial Revolution.)

A. Waterwheel

1. Undershot waterwheel — The first type of waterwheel to be used

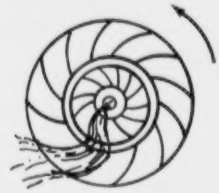


2. Overshot waterwheel — Used both the weight and the movement of water to produce power

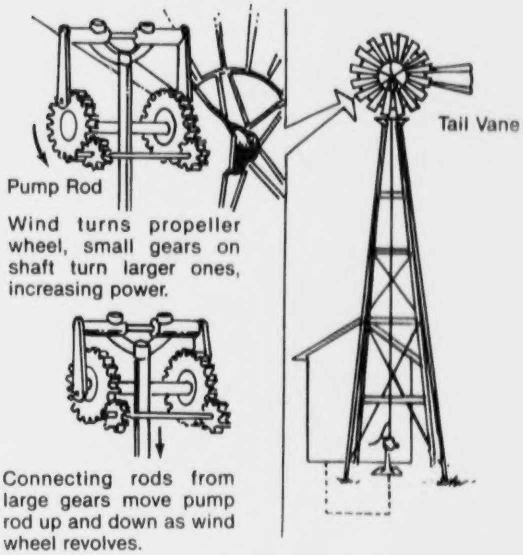


INFORMATION SHEET

B. Water turbine — More efficient machine than the waterwheel, with increased power output



C. Windmills — Use the wind for power



Wind turns propeller wheel, small gears on shaft turn larger ones, increasing power.

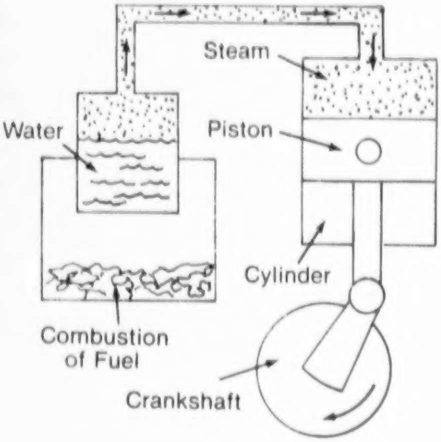
Connecting rods from large gears move pump rod up and down as wind wheel revolves.

INFORMATION SHEET

D. Engines

1. External combustion — Heat engine that uses heat and pressure produced outside of the engine.

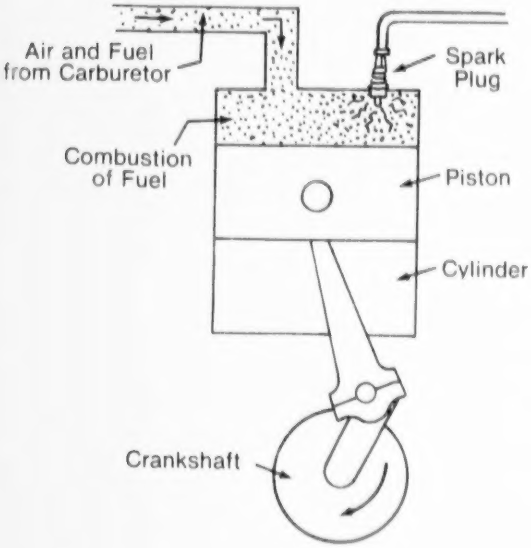
   Examples: Steam engine, steam turbine, stirling cycle engine


Steam
Water
Piston
Cylinder
Combustion of Fuel
Crankshaft

External Combustion Engine
(Steam Engine)

2. Internal combustion — A heat engine in which the heat and pressure are produced inside the engine.

   Examples: Gasoline piston (two-stroke and four-stroke cycle), diesel, rotary, diesel-electric, jet, rocket


Air and Fuel from Carburetor
Spark Plug
Combustion of Fuel
Piston
Cylinder
Crankshaft

Internal Combustion Engine
(Gasoline)

INFORMATION SHEET

IX. **Conservation of resources within the technology systems**

(NOTE: When learning about energy, power, and transportation technology, it is important to understand the problems as well as the benefits of the technology. One of the problems is that most common fuels are limited and exhaustible and must be conserved.)

A. Transportation

1. Design and use more efficient engines.
2. Use alternative fuels.
3. Use lightweight materials for vehicle design (so less fuel is needed).

B. Production (manufacturing and construction)

1. Utilize waste heat.
2. Use more efficient furnaces.
3. Practice worker conservation.

   Examples: Employees can limit engine and utility use. Employees can develop a "conservation attitude".

4. Develop more energy efficient residences and businesses.
5. Use alternative energy sources.

C. Communication

1. Utilize alternative energy sources.

   Example: Solar

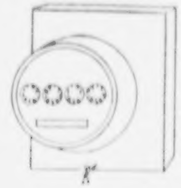
2. Develop more efficient methods.

INFORMATION SHEET

X. **Reading a gas or electric meter**

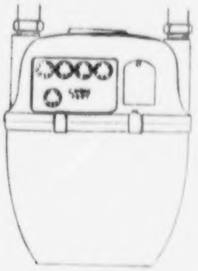
A. Electric meter — Measures the amount of electricity used in a unit called kilowatt-hours

(NOTE: A kilowatt-hour (kWh) is 1000 watts of electricity flowing for one hour. Each kWh of electricity will cost a specific amount.)

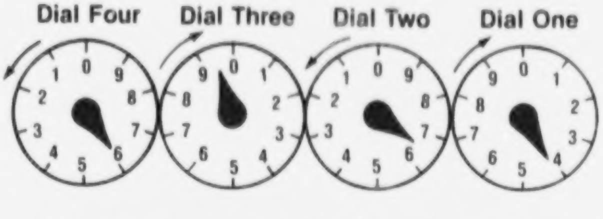


1. Four dial meter — Multiply the reading by ten
2. Five dial meter — Read direct; do not multiply by ten

B. Natural gas meter — Reads the same way as electric meters, except they measure in thousand cubic feet of gas. You must multiply the reading by 1000 (add three zeros to the reading).



(NOTE: A gas billing may read 6.8 mcf, 1000 cubic feet, or 68 ccf, cubic feet.)



1. Always read the set of dials from *Right* to *Left*.
2. Notice the direction of the arrows.

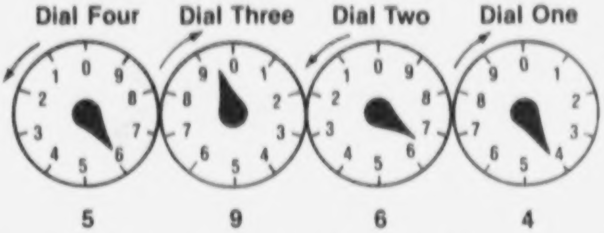
INFORMATION SHEET

3. Read the smaller number when the pointer is between arrows.

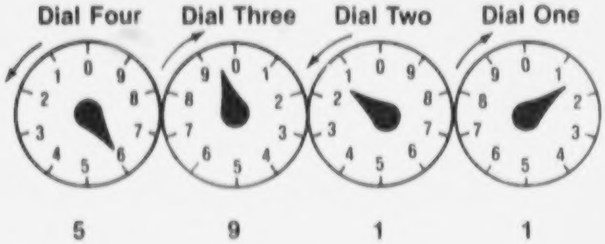
4. Reread the dial to the right when the pointer is aimed directly at a number.

5. Write down the number indicated by the pointer if the pointer on the right has passed 0

6. Write down the number next lowest to the number indicated on the first dial if the dial pointer on the right has not passed 0.

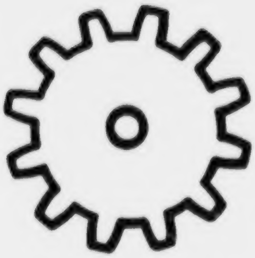

Dial Four
Dial Three
Dial Two
Dial One
5
9
6
4

7. Calculate energy use. Subtract this reading from the previous month's reading as shown below.

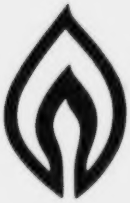

Dial Four
Dial Three
Dial Two
Dial One
5
9
1
1

5964	This month's reading
-5911	Last month's reading
53	would be 5.3 mcf or 53 ccf of gas or 530 kwh of electricity

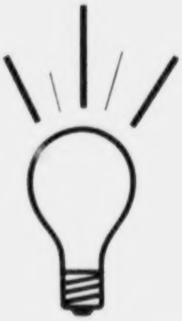
Forms of Energy



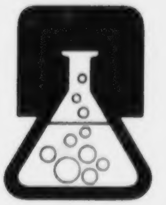
Mechanical



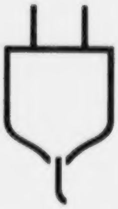
Heat



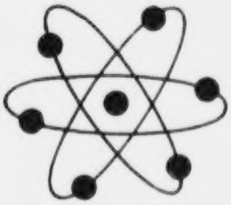
Light



Chemical

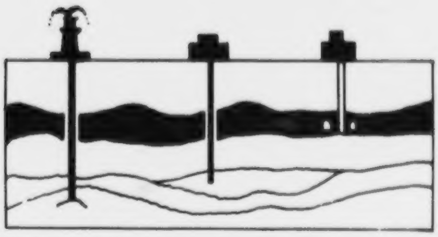


Electrical

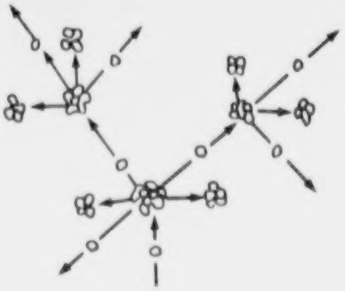


Nuclear

Classifications of Energy Sources

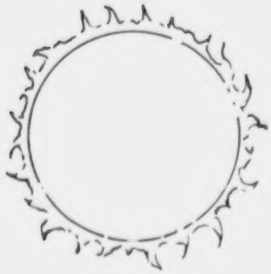


Fossil Fuels

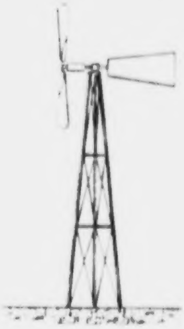


Uranium

Nonrenewable

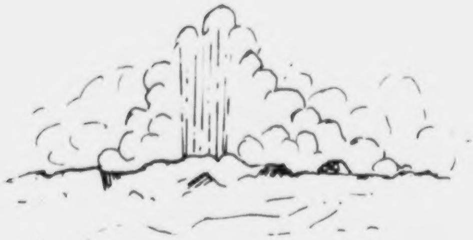


Sun

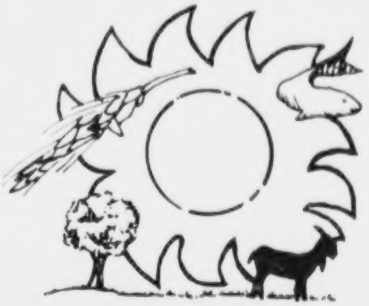


Wind

Water



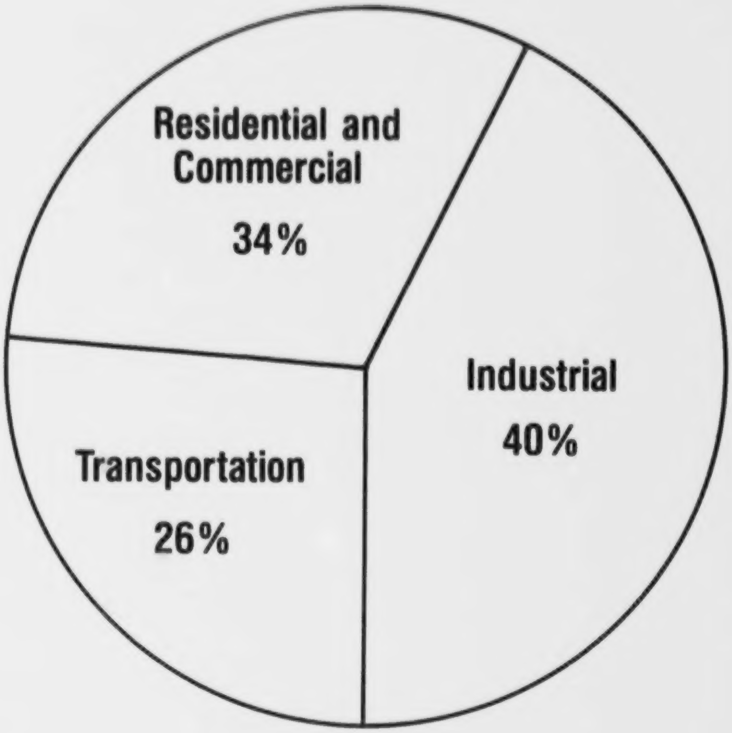
Geothermal



Plants and Waste Products
(Biomass Conversion)

Renewable

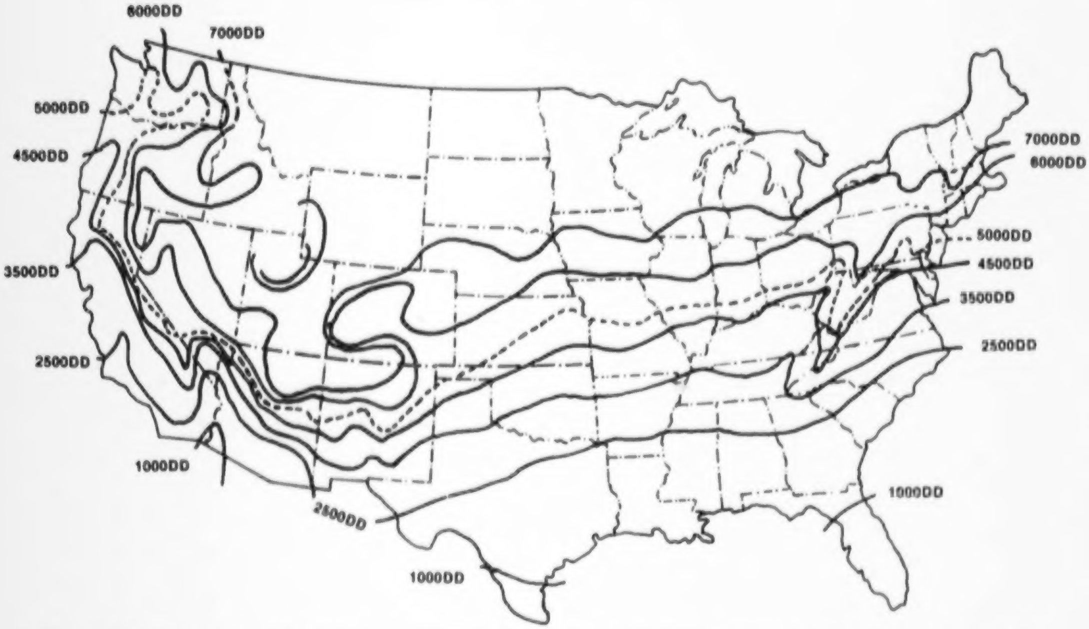
Use of Energy in the U.S.



OVERVIEW OF ENERGY AND POWER
UNIT I

HANDOUT #1 — CONSERVATION OF ENERGY

Normal Number of Degree-Days Per Year


6000DD
7000DD
5000DD
4500DD
3500DD
2500DD
1000DD
2500DD
1000DD
7000DD
6000DD
5000DD
4500DD
3500DD
2500DD
1000DD

This map is reasonably accurate for most parts of the United States but is necessarily highly generalized, and consequently not too accurate in mountainous regions, particularly in the Rockies.

RECOMMENDED INSULATION R VALUES

DEGREE DAYS	CEILINGS	WALLS	FLOORS
Above 7000	38	17	19
6001-7000	38 (30F)	17 (12F)	19 (11F)
4501-6000	30	17 (12F)	19 (11F)
3501-4500	30	12 (17E)	11 (19E)
2501-3000	22 (30E)	11 (17E)	0 (11E)
1001-2500	19 (22E)	11 (12E)	0
1000 and under	19	11	0

Fossil fuel (gas & oil) = F
Electric resistance heat = E
Heat pumps with electric heat = H
R Values apply to all unless otherwise shown.

These insulation "R" values are recommended to meet the FHA Minimum Property Standards for thermal resistance. The R value shown for walls can be met with any combination of sheathing and cavity wall insulation, or blanket insulation alone. For additional information, refer to Owens-Corning Pub. No. 5-BL-9293-A.

HANDOUT #1

RESISTANCE OF VARIOUS INSULATING MATERIALS

MATERIAL	R VALUE PER IN.	INCHES NEEDED FOR VALUE INDICATED				
		R-11	R-19	R-22	R-34	R-38
Batts/Blankets						
Fiberglass	3.14	3.5	6	7	11	12.5
Rock Wool	3.14	3.5	6	7	11	12.5
Loose/Machine Blown						
Glass Fiber	2.25	5	8.5	10	15.5	17
Rock Wool	3.125	3.5	6	7	11	12.5
Cellulose	3.75	3	5.5	6	9.5	10.5
Hand Poured Loose Fill						
Cellulose	3.7	3	5.5	6	9.5	10.5
Rock Wool	3.125	3.5	6	7	11	12.5
Glass Fiber	2.25	5	8.5	10	15.5	17
Vermiculite	2.1	5.5	9	10.5	16.5	18
Rigid Board						
Polystyrene Beadboard	3.6	3	5.5	6.5	9.5	10.5
Extruded Polystyrene	5.41	3	5	5.5	8.5	9.5
Urethane	6.2	2	3	3.5	5.5	6.5
Glass Fiber	4	3	5	5.5	8.5	9.5

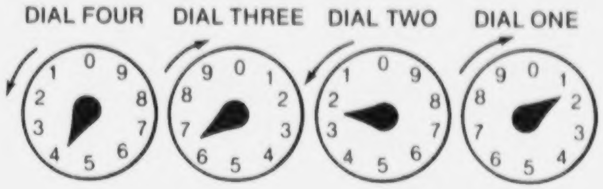
OVERVIEW OF ENERGY AND POWER
UNIT I

ASSIGNMENT SHEET #1 — READ SAMPLE METERS

NAME ____________________________________ SCORE ______________

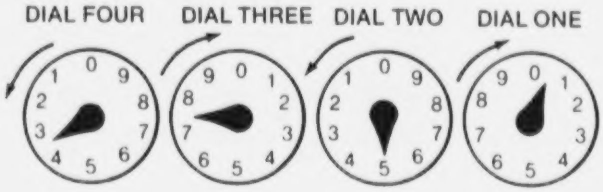
Directions: Shown below are several sets of dials. Record the correct reading in the space provided below each dial. Refer to Information Sheet, Section X if you need assistance.

1.


DIAL FOUR
DIAL THREE
DIAL TWO
DIAL ONE

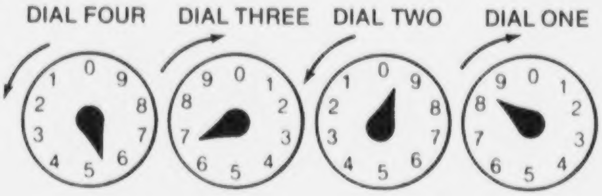
________ ________ ________ ________

2.


DIAL FOUR
DIAL THREE
DIAL TWO
DIAL ONE

________ ________ ________ ________

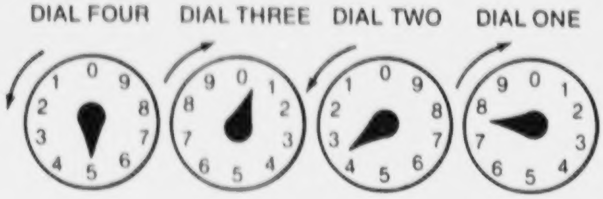
3.


DIAL FOUR
DIAL THREE
DIAL TWO
DIAL ONE

________ ________ ________ ________

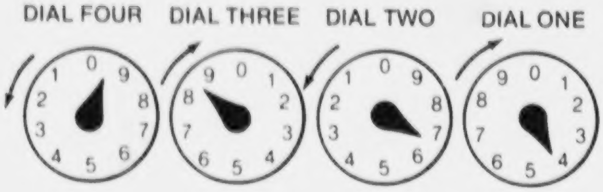
ASSIGNMENT SHEET #1

4.


DIAL FOUR
DIAL THREE
DIAL TWO
DIAL ONE

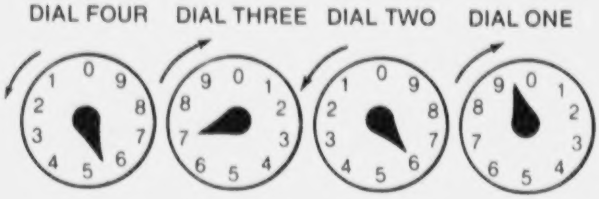
________ ________ ________ ________

5.


DIAL FOUR
DIAL THREE
DIAL TWO
DIAL ONE

________ ________ ________ ________

6.


DIAL FOUR
DIAL THREE
DIAL TWO
DIAL ONE

________ ________ ________ ________

(NOTE: Follow your instructor's directions and calculate energy use.)

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OVERVIEW OF ENERGY AND POWER
UNIT I

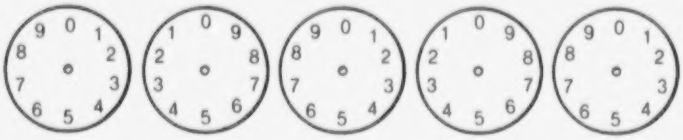
ASSIGNMENT SHEET #2 — READ HOME METER

NAME ______________________________ SCORE __________

Directions: Read your home meter for seven days and record those readings in the blanks below.

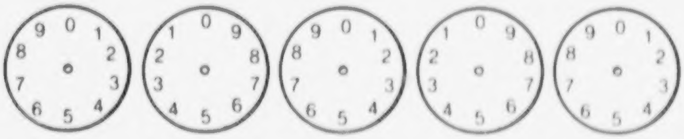
1. Make the reading at the same time each day.
2. Draw the positions of the hands of the meter on the dials below.
3. Write the number in the space below each dial.
4. If your meter does not have dials, just put the number under each drawing.
5. If your meter has only four dials, do not use the last one.

DAY 1


0 1 2 3 4 5 6 7 8 9
0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9
0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9

Meter Reading Day 1 ____________________

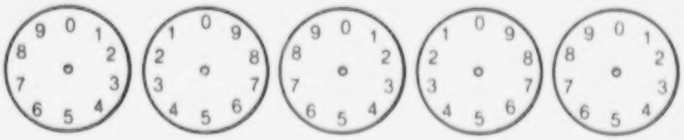
DAY 2


0 1 2 3 4 5 6 7 8 9
0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9
0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9

Reading Day 2 ____________________
Reading Day 1 ____________________
kwh/mcf used ____________________

ASSIGNMENT SHEET #2

DAY 3

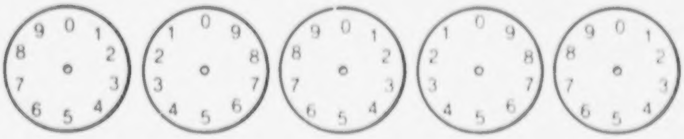


Reading Day 3 ____________________

Reading Day 2 ____________________

kwh/mcf used ____________________

DAY 4

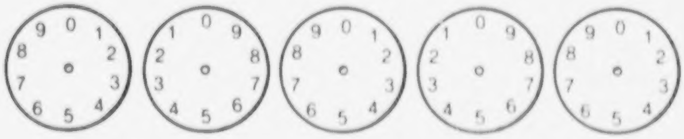


Reading Day 4 ____________________

Reading Day 3 ____________________

kwh/mcf used ____________________

DAY 5



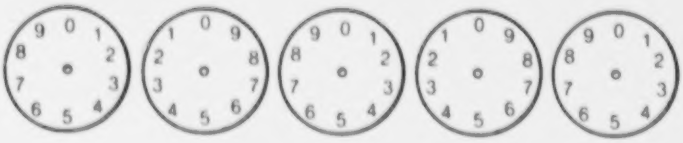
Reading Day 5 ____________________

Reading Day 4 ____________________

kwh/mcf used ____________________

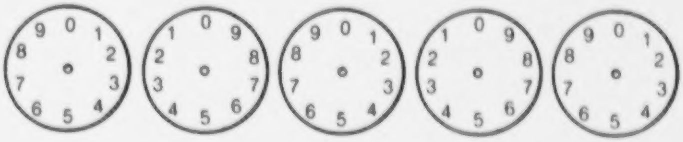
ASSIGNMENT SHEET #2

DAY 6


9 0 1 2 3 4 5 6 7 8
1 0 9 8 7 6 5 4 3 2
9 0 1 2 3 4 5 6 7 8
1 0 9 8 7 6 5 4 3 2
9 0 1 2 3 4 5 6 7 8

Reading Day 6 ____________________
Reading Day 5 ____________________
kwh/mcf used ____________________

DAY 7


9 0 1 2 3 4 5 6 7 8
1 0 9 8 7 6 5 4 3 2
9 0 1 2 3 4 5 6 7 8
1 0 9 8 7 6 5 4 3 2
9 0 1 2 3 4 5 6 7 8

Reading Day 7 ____________________
Reading Day 6 ____________________
kwh/mcf used ____________________

Now, calculate the amount of energy you and your family consumed in one week.

____
Reading on Day 7

minus

____
Reading on Day 1

equals

____
Total Weekly Use

OVERVIEW OF ENERGY AND POWER
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 4 6 2 1
2. 3 7 5 0
3. 5 6 9 8
4. 5 0 3 7
5. 9 8 6 4
6. 5 7 5 9

(NOTE: Instructor may also wish to provide a previous reading for the readings above and have students calculate kwh or mcf or ccf used.)

Assignment Sheet #2 — Evaluated to the satisfaction of the instructor

OVERVIEW OF ENERGY AND POWER
UNIT I

JOB SHEET #1 — PERFORM AN ENERGY AUDIT

A. Tools and materials

1. Thermometer (which will read 180°F)
2. Immersion thermometer
3. ½" dowel rod
4. 6" × 6" light tissue or plastic wrap
5. Masking tape

B. Procedure

1. Attach 6" × 6" paper to dowel rod with masking tape to make draft indicator.
2. Take notes on forms as you proceed using your inspection form.
3. Perform outside inspection on doors.
    a. Does house have storm doors? ______________
    b. Do doors have weatherstripping? ______________
    c. Are doors properly caulked? ______________
    d. How many layers of glass are there in the doors?
        ☐ single pane
        ☐ double pane
        ☐ triple pane
4. Perform outside inspection on windows.
    a. Do windows close tightly? ______________
    b. Are window frames properly caulked? ______________
    c. Are there any broken windows? ______________

JOB SHEET #1

d. How many layers of glass are there in the windows?

   ☐ single pane

   ☐ double pane

   ☐ triple pane

e. Are storm windows used during cold winter months? ______________

f. What kind of frames do the windows have? (wood, metal, some of each)

   ____

5. Inspect home exterior.

   a. Is re-caulking needed? ______________

   b. Are other repairs needed to prevent heat loss? ______________

   c. Are plumbing entries tightly sealed? ______________

   d. Are crawl-space entries sealed? ______________

   e. Are mail-slots closing tightly? ______________

   f. Are dryer outlets sealed? ______________

   g. Are air-conditioning outlets sealed? ______________

   h. Are other exhaust outlets sealed? ______________

6. Perform inside inspection for airleaks.

   a. Shut off forced-air furnace (if used in your home) and using draft indicator check doors. Are there air leaks? ______________

   b. Are there leaks around windows? ______________

   c. Are there leaks around corners fo exterior walls? ______________

   d. Are there leaks around floor and floor boards? ______________

   e. Are there leaks around plumbing entries under sinks along exterior walls? ______________

   f. Are there leaks around electrical outlets on exterior walls? ______________

   g. Turn heat back on if you turned it off in Step 6a.

JOB SHEET #1

7. Perform inside inspection of windows.

   a. How are windows covered to control light and prevent heat loss and gain?

   Blinds ______ Drapes ______

   Shutters ______ Reflective coating ______

   Shades ______ Other ______

   Curtains ______ None ______

   b. How many windows are located on each outside wall?

   North ______ South ______

   East ______ West ______

8. Inspect insulation and find out what kind of insulation the home has.

   a. Is there blown-in or blanket insulation in the attic or ceiling area? __________ What thickness? __________ What R-value? __________

   b. Is there insulation in the walls? __________

   c. Is there insulation in the floors/foundation? __________

   d. Complete the following chart if the information is available.

FIGURE 1

Area	Recommended R-value	Insulation		R-value of Insulation
		Yes	No	
Ceiling/Roof				
Walls				
Floors/ Foundation				

JOB SHEET #1

9. Inspect lighting.

    a. Are lights left on in rooms or areas when not in use? ____________

    b. Are fluorescent bulbs used in lights and fixtures whenever possible? ____________

    c. Are walls a light color for good reflection? ____________

    d. What kind of natural lighting is used? (windows, skylights) ____________

10. Inspect fireplace if the home has one.

    a. Is the vent closed when not in use? ____________

    b. Does fireplace have glass doors to prevent heat loss? ____________

    c. Does fireplace have a method of circulating air and heat? ____________

11. Inspect hot water heater.

    a. Check water temperature with thermometer.

    b. Record temperature. ____________

    c. Are hot water pipes and water heater insulated? ____________

    d. Are any hot water faucets leaking? ____________

    e. Are the clothes washer and dishwasher used only with full loads? ____________

    f. Are flow restrictors used on shower heads and sink faucets? ____________

JOB SHEET #1

12. Check heating, ventilation, and air conditioning.

    a. Complete the following table (change names to fit rooms in the home.)

    FIGURE 2

Room	Actual Temp.	Heat or Air Cond. Register		Thermostat in Room		Thermostat Setting
		Open	Closed	Yes	No	
Living						
Dining						
Kitchen						
Bathroom						
Bedroom 1						
Bedroom 2						
Hall						

    b. Is the thermostat set back to a lower temperature at night? ____________

    c. Is the thermostat set at 65°F or lower in the heating season and 78°F or higher in the cooling season? ____________

    d. Is the heating system forced air or a convection system? ____________

    e. Are heating and cooking vents clean and unblocked? ____________

    f. Are there filters on air conditioners and furnaces? ____________

    g. Are filters clean and unclogged? ____________

    h. Are air ducts insulated? ____________

    i. Are hot water pipes insulated? ____________

    j. Are kitchen and bathroom exhaust fans turned off when not needed? ____________

JOB SHEET #1

13. Make recommendations for improvements by filling in the chart below.

LOW COST RECOMMENDATIONS	HIGH COST RECOMMENDATIONS

OVERVIEW OF ENERGY AND POWER
UNIT I

PRACTICAL TEST
JOB SHEET #1 — PERFORM AN ENERGY AUDIT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask you instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Made draft indicator.	______	______
3.	Performed and noted outside inspections on doors.	______	______
4.	Performed and noted outside inspections on windows.	______	______
5.	Inspected home exterior and made notes.	______	______
6.	Performed and noted inside inspection for air leaks.	______	______
7.	Inspected insulation and made notes.	______	______
8.	Inspected lighting and made notes.	______	______
9.	Inspected fireplace (if home has one) and made notes.	______	______
10.	Inspected hot water heater and made notes.	______	______
11.	Checked and noted heating.	______	______
12.	Checked and noted ventilation.	______	______
13.	Checked and noted air conditioner.	______	______
14.	Made recommendations for improvements.	______	______
15.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
16.	Practiced safety rules throughout procedure.	______	______
17.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Draft indicator	Meets Requirements	Minor Adjustment	Major Adjustment	Redo
	4	3	2	1
Audit	Thorough Inspection	Satisfactory Inspection	Incomplete Inspection	Unsatisfactory/ Redo Inspection
	4	3	2	1
Forms	Thorough Forms	Satisfactory Forms	Incomplete Forms	Unsatisfactory/ Redo

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

OVERVIEW OF ENERGY AND POWER
UNIT I

NAME ______________________ SCORE ______________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. Heat engine that requires two piston strokes to produce a single power stroke

_____b. A form of energy traveling as wave motion, such as rays from the sun

_____c. The increase in force that you gain from using a machine

_____d. Rotating device driven by wind or water that is used to provide power

_____e. The ability to do work, or the capacity to produce motion, heat, or light

_____f. Force applied *to* the machine

_____g. A rating given a material's resistance to passage of heat

_____h. Energy or work per unit of time, or work accomplished in a given period of time

_____i. An engine that requires four strokes of the piston to produce a single power stroke

1. Radiant energy
2. Two-stroke cycle engine
3. Power
4. R-value
5. Energy
6. Effort
7. Four-stroke cycle engine
8. Mechanical advantage
9. Turbine
10. Resistance

2. Match the forms of energy on the right with the correct definitions.

_____a. The energy of motion

_____b. The visible part of radiant energy

_____c. The motion of electrons

_____d. Energy produced by reactions in the nuclei of atoms

_____e. Energy produced by chemical changes

1. Nuclear energy
2. Chemical energy
3. Electrical energy
4. Heat energy
5. Mechanical energy
6. Light energy

TEST

3. Select true statements concerning the classifications of energy sources by placing an "X" next to the true statements. Leave false statements blank.

_____a. Nonrenewable energy sources can be used indefinitely if properly managed.

_____b. Fossil fuels were originally deposited millions of years ago.

_____c. Wind can be used to generate electricity through modern wind machines.

_____d. Photovoltaic cells absorb sunlight and turn it directly into chemical energy.

_____e. The differences between high tide and low tide can be used to turn turbines and generate electricity.

_____f. Natural examples of geothermal energy are trees and farm crops.

_____g. Geothermal energy can be applied everywhere in the U.S. because all geothermal reservoirs are very close to the earth's surface.

_____h. Falling or flowing water can be used to generate electricity.

_____i. Examples of fossil fuels are natural gas, coal, and oil.

_____j. Uranium is primarily used for heating and cooling homes.

_____k. Fossil fuels and uranium are renewable energy sources.

_____l. Wind, sun, water, and trees are renewable energy sources.

_____m. A product of biomass conversion is methane.

_____n. The largest commercial geothermal electric power plant complex is The Geysers in northern California.

_____o. Tremendous amounts of energy are released when the nucleus of uranium atoms are split.

4. Discuss how fire, wind, water, and the sun were used as early energy sources.

a. Fire ______________________________

b. Wind ______________________________

c. Water ______________________________

d. Sun ______________________________

TEST

5. List two present day uses of energy.

   a. Residential and commercial areas — ______________________

   ____

   b. Industrial areas — ______________________

   ____

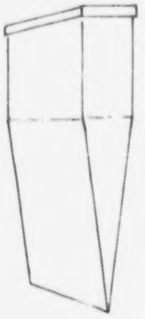
6. List three early sources of power.

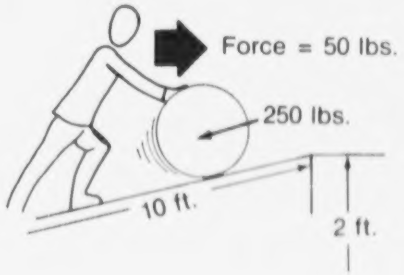
   a. ______________________

   b. ______________________

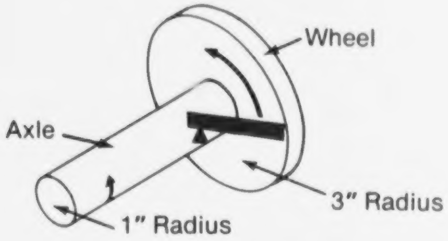
   c. ______________________

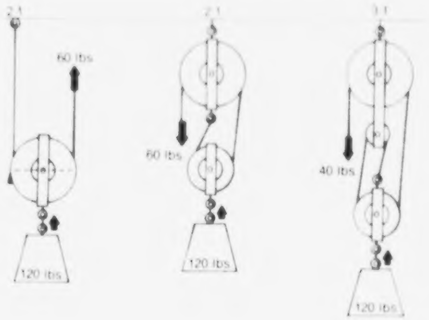
7. Identify the following simple machines.




Force = 50 lbs.
250 lbs.
10 ft.
2 ft.

a. ______________________ b. ______________________

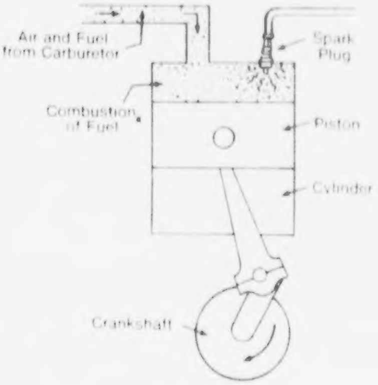

Wheel
Axle
3" Radius
1" Radius

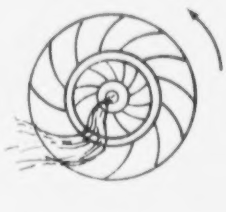

2:1
60 lbs
120 lbs
2:1
60 lbs
120 lbs
3:1
40 lbs
120 lbs

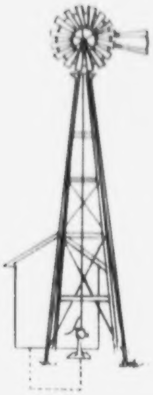
c. ______________________ d. ______________________

TEST

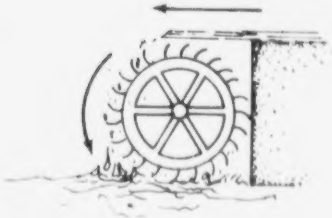
8. Identify the following complex machines.

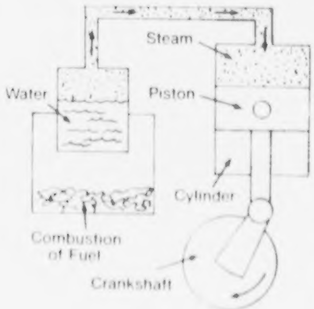

Air and Fuel from Carburetor
Spark Plug
Combustion of Fuel
Piston
Cylinder
Crankshaft





a. ____________________ b. ____________________ c. ____________________




Steam
Water
Piston
Cylinder
Combustion of Fuel
Crankshaft

d. ______________________________ e. ______________________________

9. Discuss ways to conserve energy resources within the following technology systems:

a. Transportation ____

____

____

____

TEST

b. Production (manufacturing and construction) ________________________________

____

____

____

c. Communication ____

____

____

____

10. a. Natural gas meters measure fuel use in ____________ unit of measure.

b. Electric meters measure electrical use in ____________ unit of measure.

c. Always read meter dials ____________ to ____________.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

11. Read sample meters. (Assignment Sheet #1)

12. Read home meter. (Assignment Sheet #2)

13. Demonstrate the ability to perform an energy audit. (Job Sheet #1)

OVERVIEW OF ENERGY AND POWER
UNIT I

ANSWERS TO TEST

1. a. 2
   b. 1
   c. 8
   d. 9
   e. 5
   f. 6
   g. 4
   h. 3
   i. 7

2. a. 5
   b. 6
   c. 3
   d. 1
   e. 2

3. b, c, e, h, i, l, m, n, o

4. Answers should include the following information:
   a. Fire — Used for heating, cooking, and tool making
   b. Wind — Used for sailing and windmills
   c. Water — Used in water wheels and turbines to grind grain and irrigate crops
   d. Sun — Used for light and heat

5. Answer should include two for each of the following:
   a. Residential and commercial areas
      1) Lighting
      2) Heating and cooling
      3) Cooking
      4) Operating appliances and equipment
   b. Industrial areas
      1) Mining
      2) Processing
      3) Manufacturing materials into products
      4) Generating electricity

6. a. Human
   b. Animals
   c. Simple machines

7. a. Wedge
   b. Inclined plane
   c. Wheel and axle
   d. Pulley

8. a. Internal combustion engine
   b. Water turbine
   c. Windmill
   d. Waterwheel
   e. External combustion engine

ANSWERS TO TEST

9. Answer should include the following:
   a. Transportation
      1) Design and use more efficient engines.
      2) Use alternative fuels.
      3) Use lightweight materials for vehicle design.
   b. Production (manufacturing and construction)
      1) Utilize waste heat.
      2) Use more efficient furnaces.
      3) Practice worker conservation.
      4) Develop more energy efficient residences and businesses.
      5) Use alternative energy sources.
   c. Communication
      1) Utilize alternative energy sources.
      2) Develop more efficient methods.

10. a. Cubic feet
    b. Kilowatt-hours
    c. Right to left

11.-12. Evaluated to the satisfaction of the instructor

13. Performance skills evaluated to the satisfaction of the instructor

PRINCIPLES OF ENERGY AND POWER
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to measure mechanical and electrical power, and build a steam turbine, a wind rotor, and an electric generator. Competencies will be demonstrated by completing the assignment sheets, job sheets, and unit tests with a minimum of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to principles of energy and power with the correct definitions.
2. List the types of power systems.
3. Arrange in order the stages of power systems.
4. Distinguish between the basic measuring systems.
5. Complete a chart of basic units of measurement.
6. Use prefixes for changing metric base units.
7. State units for measuring energy and power.
8. Match terms related to measuring mechanical power with the correct definitions.
9. Calculate problems using the formula for work. (Assignment Sheet #1)
10. Calculate problems using the formula for horsepower. (Assignment Sheet #2)
11. Calculate problems using the formula for torque. (Assignment Sheet #3)

OBJECTIVE SHEET

12. Match terms related to measuring electrical power with the correct definitions.
13. State Ohm's law in letter formula for calculating voltage, current, and resistance.
14. Draw Ohm's law in triangle expression.
15. Solve problems using Ohm's law. (Assignment Sheet #4)
16. Demonstrate the ability to:
    a. Build and test a simple, low pressure steam turbine. (Job Sheet #1)
    b. Construct a wind rotor. (Job Sheet #2)
    c. Build an electric generator. (Job Sheet #3)

PRINCIPLES OF ENERGY AND POWER
UNIT II

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

1. Show films which demonstrate the principles of energy and power.
2. Combine steam turbine (Job Sheet #1) by pulley to electric generator (Job Sheet #3) and measure electricity produced.
3. Vary rotor design of the blades on a steam turbine (Job Sheet #1) and measure the differences in energy produced. Determine the most efficient design.
4. Have students apply Ohm's Law to Job Sheet #3.
5. Practical application of horsepower and torque will be demonstrated in the next unit.
6. Conduct various experiments which demonstrate the principles of energy and power.
7. Show examples of the various meters used for measuring electricity's voltage, current, and resistance.
8. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

SUGGESTED ACTIVITIES

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Bame, E. Allen, and Paul Cummings. *Exploring Technology.* Worcester, MA: Davis Publications, Inc., 1980.

B. Bohn, Ralph C., et. al. *Energy, Power, and Transportation Technology.* Peoria, IL: Bennett & McKnight, 1986.

C. *Small Engine Repair.* Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1985.

SUGGESTED SUPPLEMENTAL RESOURCES

A. Films

1. *Energy, Steam, and Progress* (26 min. color)
   Babcock and Wilcox, 1964; #07665, available from University of Wisconsin at Madison (608-262-1644) or write P.O. Box 2093; Madison, Wisconsin 53701-2093

2. *Energy and Work* (11 min. color)
   EBE, 1961; #05859; available from University of Wisconsin at Madison (608-262-1644) or write P.O. Box 2093; Madison, Wisconsin 53701-2093

3. *Great Search: Man's Need for Power and Energy* (13 min. color)
   Disney, 1972; #09475; available from University of Wisconsin at Madison (608-262-1644) or write P.O. Box 2093; Madison, Wisconsin 53701-2093

B. *Principles of Technology* Teacher and student guides and videocassettes (14 units). Available from your state curriculum lab or the Agency for Instructional Technology, Box A, Bloomington, IN 47402-0120, or call 812-339-2203 or 800-457-4509.

1. *Force*
2. *Work*
3. *Rate*
4. *Resistance*
5. *Energy*
6. *Power*

PRINCIPLES OF ENERGY AND POWER
UNIT II

INFORMATION SHEET

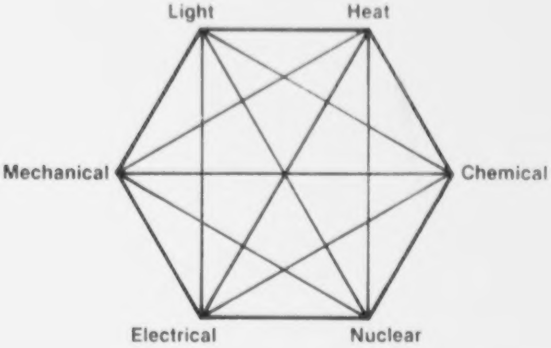
I. **Terms and definitions**

A. Ammeter — An instrument used to measure the amount of current in a circuit

B. Ampere — Unit of measure for electrical current

C. Efficiency — The percentage of available energy converted into usable energy

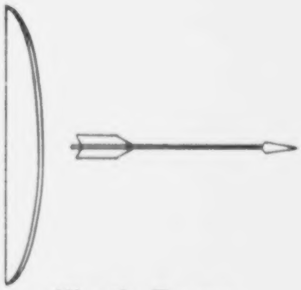
D. Energy conversion — The process of changing energy from one of its six forms into another



E. Friction — The resistance to motion produced when two objects rub against each other

(NOTE: Friction produces heat energy.)

F. Kinetic energy — Energy in motion



Kinetic Energy

INFORMATION SHEET

G. Law of conservation of energy — The amount of energy in the universe is fixed; it cannot be created or destroyed

H. Multimeter — A meter that can measure different values such as voltage, current, and resistance

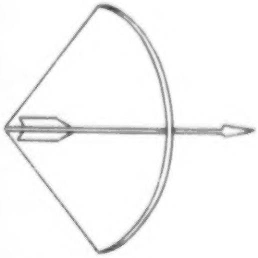
I. Ohm — Standard unit of measuring resistance to current flow

J. Ohmmeter — An instrument used to measure resistance to current flow

K. Potential energy — Stored or available energy

(NOTE: When used, potential energy becomes kinetic energy.)

Examples: Fossil fuels, uranium, food, water behind a dam

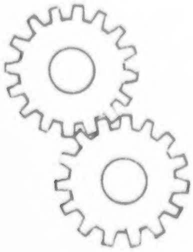


Potential Energy

L. Voltmeter — An instrument used to measure the amount of voltage in a circuit

II. **Types of power systems**

A. Mechanical power — Utilizes simple and complex machines to control and transmit motion.



INFORMATION SHEET

B. Electrical power — Utilizes and controls the motion of electrons through conductive materials to transmit electricity.

C. Fluid power — Utilizes gases or liquids to control and transmit motion.

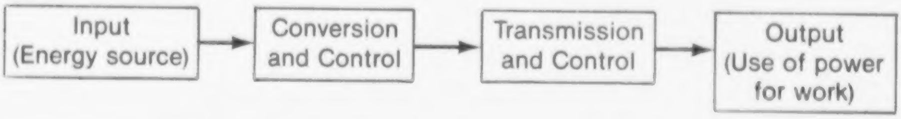
III. Stages of the basic power theory (Transparency 1)

A. Input

B. Conversion and control

C. Transmission and control

D. Output


Input (Energy source)
Conversion and Control
Transmission and Control
Output (Use of power for work)

IV. Basic measuring systems

A. English — Measuring system traditionally used in the United States; basic units are the foot, the pound, and degree Fahrenheit

B. Metric — Measuring system used by most of the industrial countries of the world; basic units are the meter, the liter, and degree Celsius

(NOTE: This system is formally called the International System of Unit, abbreviated as SI.)

INFORMATION SHEET

V. Basic units of measurement — Metric and English

Measurement	Metric Units	English Units
A. Length	millimeters centimeters meters kilometers	inches feet yards miles
B. Weight	grams kilograms metric tons	ounces pounds tons
C. Volume	milliliters liters cubic centimeters	ounces cups pints quarts gallons
D. Area	square centimeters square meters	square inches square feet square yards
E. Temperature	degrees Celsius	degrees Fahrenheit
F. Speed	kilometers per hour	miles per hour
G. Force	newtons	pounds
H. Torque	newton-meters	pound-feet
I. Pressure	pascals	pounds per sq. inch (psi) inches of mercury

INFORMATION SHEET

VI. **Prefixes for changing metric base units**

Prefix	+	Base Unit	=	Metric term	Value
milli- (m)	+	meter (m) liter (l) gram (g)	=	millimeter (mm) milliliter (ml) milligram (mg)	1/1000th of base unit
centi- (c)	+	meter liter gram	=	centimeter (cm) centiliter (cl) centigram (cg)	1/100th of base unit
kilo- (k)	+	meter liter gram	=	kilometer (km) kiloliter (kl) kilogram (kg)	1000 base units

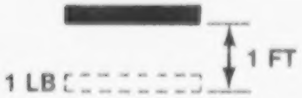
VII. **Units for measuring energy and power**

A. Energy	Metric Units	English Units
1. Mechanical	joules	foot-pounds
2. Heat	joules, calories	British thermal units
3. Electrical	joules	joules
B. Power		
1. Mechanical	watts	horsepower
2. Heat	watts	BTUs per second
3. Electrical	watts	watts

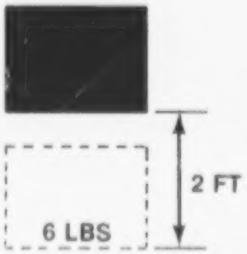
INFORMATION SHEET

VIII. Terms and definitions related to measuring mechanical power

A. Work — Measurement of useful motion (mechanical energy); measured in foot-pounds.

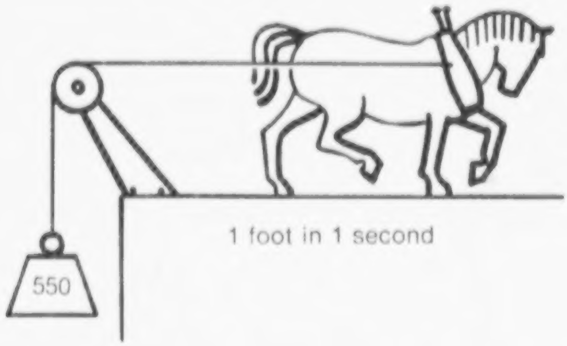


Raising one pound a distance of one foot equals one foot-pound of work



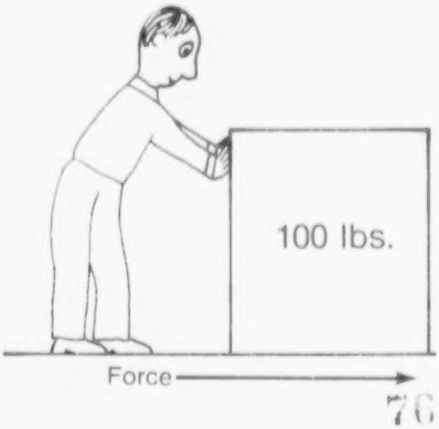
Raising six pounds two feet equals twelve foot-pounds of work

B. Power — Work per unit of time; measured in horsepower.



C. Force (F) — Any push or pull on an object; measured in pounds and newtons.

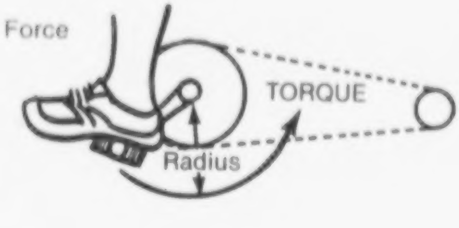
(NOTE: The term "force" should be used in all calculations of work except for those involving simple lifting when the term weight is used.)

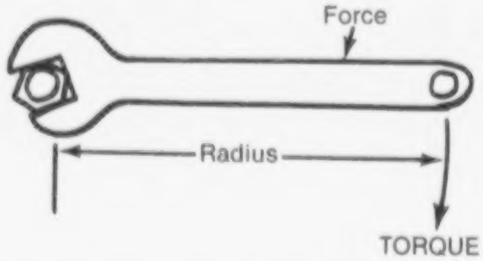


INFORMATION SHEET

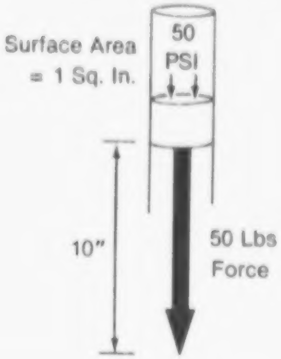
D. Torque — Turning or twisting effort; measured in pound-feet (lb-ft) or newton-meters.

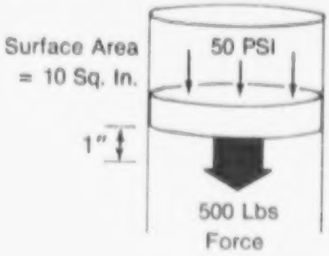
(NOTE: We use torque whenever we turn a wheel, tighten a bolt, or pedal a bicycle.)


Force
TORQUE
Radius


Force
Radius
TORQUE

E. Pressure — Force per unit of area; measured in pascals or in pounds per square inch (psi) or inches of mercury (for atmospheric pressure).


Surface Area
= 1 Sq. In.
50
PSI
10"
50 Lbs
Force


Surface Area
= 10 Sq. In.
50 PSI
1"
500 Lbs
Force

IX. **Formula for measuring work** (Assignment Sheet #1)

Work = Force × Distance

Example: How much work is accomplished if it takes 80 pounds of force to move a 300 pound box 50 ft?

W = F × D

W = 80 × 50

W = 4000 ft.-lbs.

INFORMATION SHEET

X. **Formula for measuring horsepower** (Assignment Sheet #2)

$$\text{Horsepower} = \frac{\text{Force (or weight)} \times \text{Distance}}{\text{Time (sec)} \times 550} \text{ or } \frac{\text{Force (or weight)} \times \text{Distance}}{\text{Time (min)} \times 33{,}000}$$

Example: A 180 pound man climbs a 10 foot flight of stairs in 5 seconds. How much horsepower does he develop?

$$HP = \frac{W \times D}{\text{Time (sec)} \times 550}$$

$$HP = \frac{180 \times 10}{5 \times 550}$$

$$HP = \frac{1800}{2750}$$

HP = .65 horsepower

XI. **Formula for measuring torque** (Assignment Sheet #3)

Torque = Force × Radius

Example: If 25 pounds of force is applied to a wrench 2 feet long, what is the torque?

$T = F \times R$

$T = 25 \times 2$

T = 50 lb.-ft.

XII. **Terms and definitions related to measuring electrical power** (Transparency 2)

(NOTE: Electricity can be measured by finding the number of electrons moved from one place to another. Electrons are small and an enormous number is needed to generate a small amount of electricity. The basic unit of measurement for electricity is the coulomb. One coulomb is equal to 6,280,000,000,000,000,000 [or 6.28×10^{18}] electrons.)

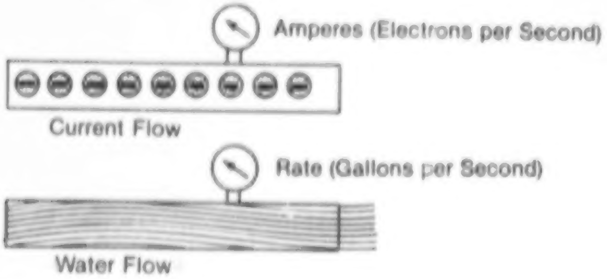
A. Amperage

1. The rate at which current flows through a conductor
2. One "amp" is equal to one coulomb of electricity passing a given point in one second.

INFORMATION SHEET

3. In calculations, the sign for amperage is I.

Example: Compare amperage to the rate at which water flows through a water line.

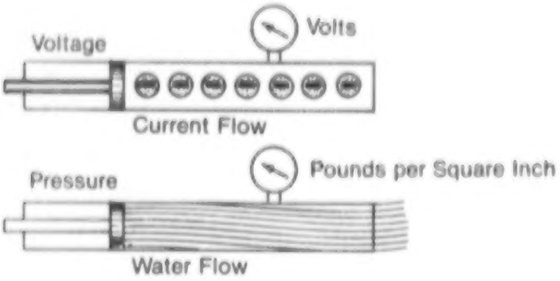

Amperes (Electrons per Second)
Current Flow
Rate (Gallons per Second)
Water Flow

B. Voltage

1. The pressure pushing the current through the conductor

2. One "volt" is the pressure that moves one coulomb of electricity through a resistance of one ohm in one second.

3. In calculations, the sign for voltage is E.


Voltage
Volts
Current Flow
Pressure
Pounds per Square Inch
Water Flow

C. Resistance

1. The opposition to current flow through a conductor

2. Measured in "ohms"

3. In calculations, the sign for resistance is R.

XIII. **Ohm's Law in letter formula** (Transparency 3 and Assignment Sheet #4)

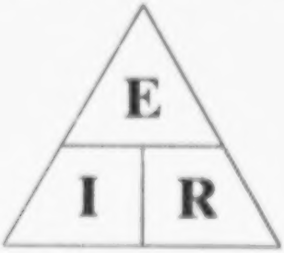
A. For calculating voltage: E = I × R or Volts = Amps × Ohms

B. For calculating amperage: I = E/R or Amps = Volts ÷ Ohms

C. For calculating resistance: R = E/I or Ohms = Volts ÷ Amps

INFORMATION SHEET

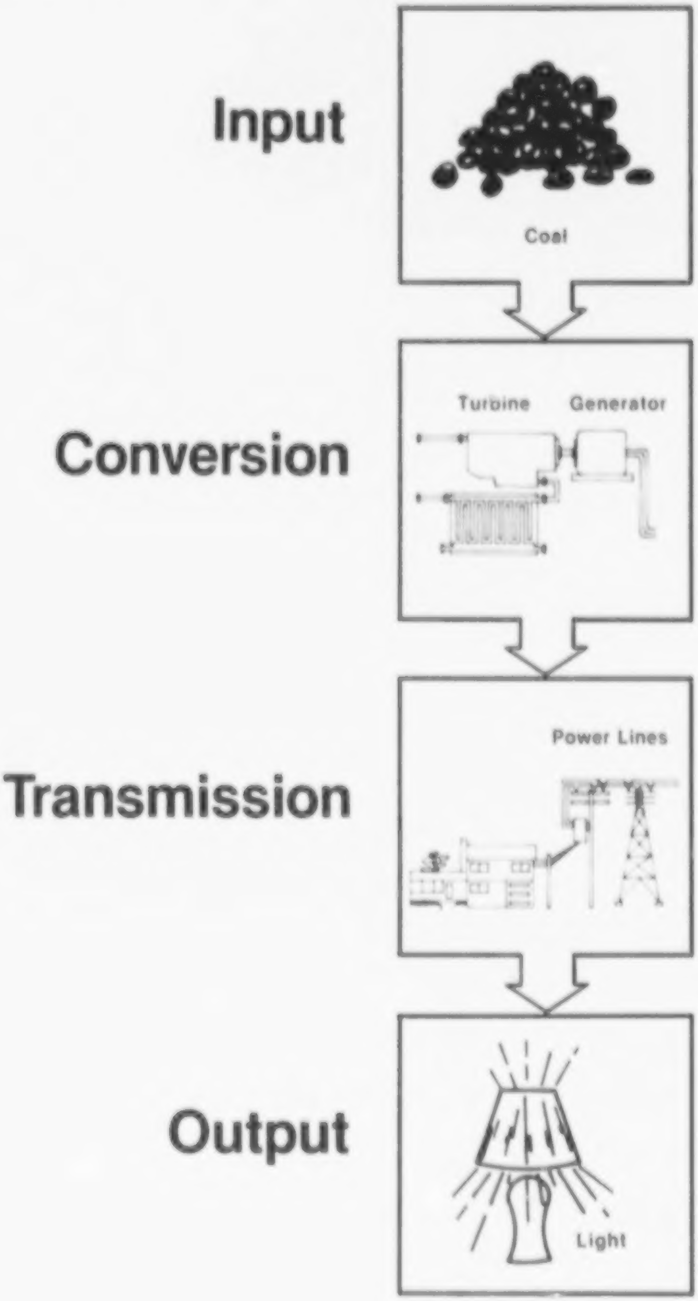
XIV. **Ohm's Law in triangle expression** (Transparency 4)



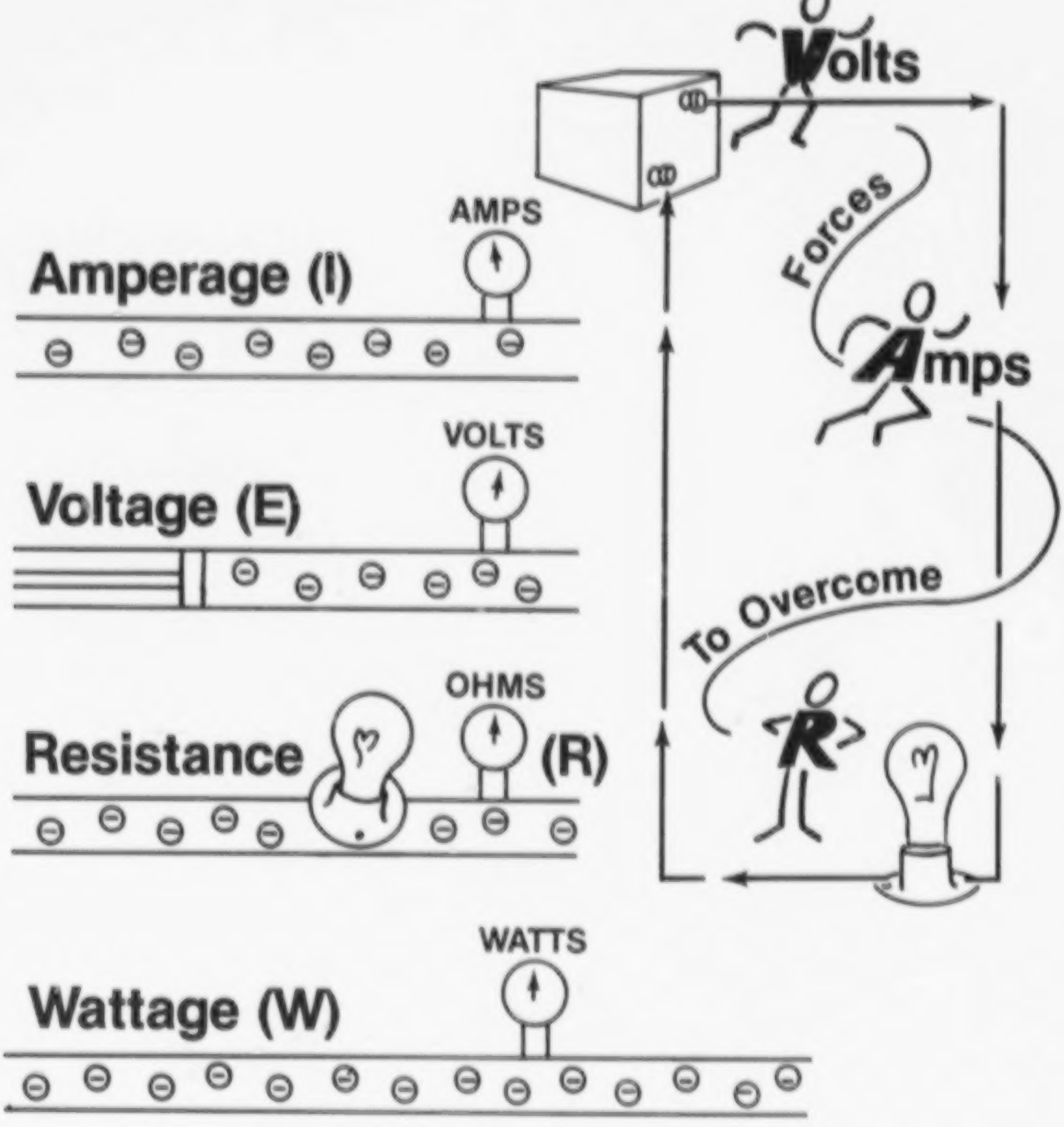
(NOTE: A reminder for the E.I.R. formula is the phrase "Even I Remember.")

Stages of Power Theory

(Example of Electrical Power Shown)


Input
Coal
Conversion
Turbine
Generator
Transmission
Power Lines
Output
Light

Measurement of Electricity


Volts
Forces
Amps
To Overcome
R
AMPS
Amperage (I)
VOLTS
Voltage (E)
OHMS
Resistance
(R)
WATTS
Wattage (W)

Ohm's Law in Letter Formula

Electromotive Force = Current × Resistance

Volts = Amperes × Ohms

$$E = I \times R$$

$$\text{Current} = \frac{\text{Electromotive Force}}{\text{Resistance}}$$

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

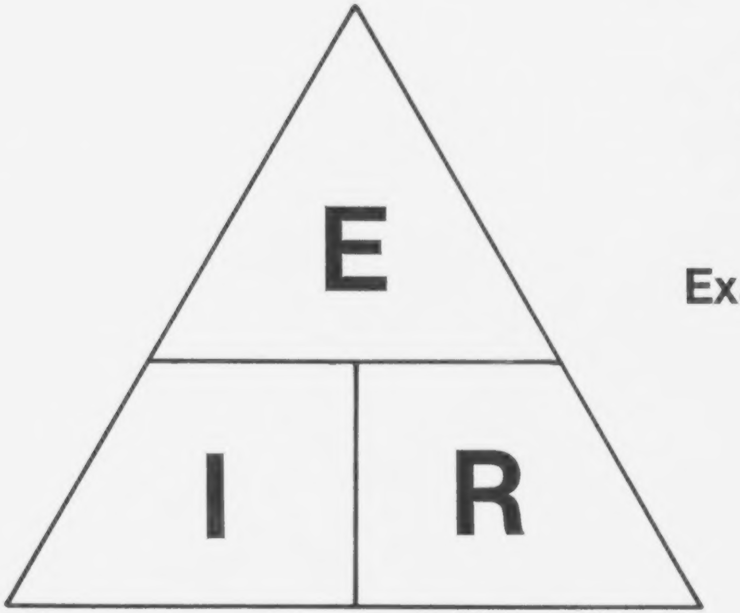
$$I = \frac{E}{R}$$

$$\text{Resistance} = \frac{\text{Electromotive Force}}{\text{Current}}$$

$$\text{Ohms} = \frac{\text{Volts}}{\text{Amperes}}$$

$$R = \frac{E}{I}$$

Ohm's Law in Triangle Expression



E = Volts
I = Amps R = Resistance

NOTE: Solve for Volts, Amps, or Resistance by Covering the Unknown

Example: Cover E, then E = I × R
Cover I, then I = E ÷ R
Cover R, then R = E ÷ I

PRINCIPLES OF ENERGY AND POWER
UNIT II

ASSIGNMENT SHEET #1 — CALCULATE WORK

NAME ______________________________ SCORE __________

Directions: Calculate the following problems using the formula for work:

Work = Force × Distance

1. One man pushes a 200 pound weight a distance of 60 feet along a warehouse floor. The force necessary to slide the weight is 100 pounds. How much work is accomplished?

   Answer: ______________________________

2. How much work is accomplished if it takes 75 pounds of force to move a 350 pound object 50 feet?

   Answer: ______________________________

3. It takes 78 pounds of force to move a 230 pound box 40 feet across the floor. How much work is accomplished?

   Answer: ______________________________

PRINCIPLES OF ENERGY AND POWER
UNIT II

ASSIGNMENT SHEET #2 — CALCULATE HORSEPOWER

NAME ______________________________ SCORE __________

Directions: Calculate the following problems using the formula for horsepower:

$$HP = \frac{F \times D}{\text{Time (sec)} \times 550} \text{ or } \frac{F \times D}{\text{Time (min)} \times 33{,}000}$$

1. A 100 pound woman climbs a 40 foot flight of stairs in 20 seconds. How much horsepower does she develop performing the task?

   Answer: ______________________________

2. A 1000 pound weight is moved a distance of 50 feet across the floor. The force necessary to move the weight is 190 pounds and the time required is one minute. How much horsepower is required to perform this task?

   Answer: ______________________________

3. A 500 pound weight is moved a distance of 10 feet along a loading dock. The force required to move the weight is 500 pounds. The task is completed in 5 seconds. How much horsepower is produced?

   Answer: ______________________________

(NOTE: Practical application for calculating horsepower can be applied in Job Sheet #1, Unit III.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

ASSIGNMENT SHEET #3 — CALCULATE TORQUE

NAME ____________________ SCORE ____________

Directions: Calculate the following problems using the formula for torque:

Torque = Force × Radius

1. If a mechanic uses a wrench 10 inches long and applies a 20 pound force to the wrench handle, what is the torque on the bolt?

   Answer: ____________________

2. If 15 pounds of force is applied to a wrench 8 inches long, how much is the torque?

   Answer: ____________________

3. What is the torque if a force of 10 pounds is applied to a wrench 1 foot long?

   Answer: ____________________

(NOTE: Practical application of calculating torque can be applied in Job Sheet #1, Unit III.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

ASSIGNMENT SHEET #4 — SOLVE PROBLEMS USING OHM'S LAW

NAME ______________________________ SCORE __________

Directions: Read the problems and use the triangle expression of Ohm's law to solve for the unknown value in each problem.

Example: Cover the unknown in the triangle and solve. Show your work on each problem.

(NOTE: E = Voltage; I = Amperes; R = Resistance)

1. A current of 5 amperes is needed to operate a certain light bulb having a resistance of 4 ohms. What voltage is required?

   Answer: ______________________________

2. If it takes 10 volts to produce a current of 10 amperes, how many ohms of resistance are present?

   Answer: ______________________________

3. An electric horn requires 12 volts. The resistance is 20 ohms. What current does the horn take?

   Answer: ______________________________

(NOTE: Practical application of using Ohm's Law can be applied in Job Sheet #3 of this unit.)

ASSIGNMENT SHEET #4

(NOTE: The electrical energy consumed in any resistance appears as heat. There is a definite relation between the power consumed and the heat produced. This is in accordance with the principle that energy cannot be destroyed.)

4. A light bulb having a resistance of 5 ohms uses 2 amperes of current while in operation. What is the voltage applied to the circuit?

   Answer: ____

5. A horn connected to a 12 volt battery uses 3 amperes of current for its operation. What is the resistance of the horn?

   Answer: ____

PRINCIPLES OF ENERGY AND POWER
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 6000 foot pounds
2. 3750 foot pounds
3. 3120 foot pounds

Assignment Sheet #2

1. .3636 or approx. $^4/_{10}$ horsepower
2. .2878 or approximately $^3/_{10}$ horsepower
3. 1.818 or 1.82 horsepower or 1 $^8/_{10}$ hp

Assignment Sheet #3

1. 200 pound-inches
2. 120 pound-inches
3. 10 pound-feet (120 pound-inches)

Assignment Sheet #4

1. 20 volts
2. 1 ohm
3. .6 amperes.
4. 10 volts
5. 4 ohms.

PRINCIPLES OF ENERGY AND POWER
UNIT II

JOB SHEET #1 — BUILD AND TEST A SIMPLE, LOW PRESSURE STEAM TURBINE

A. Tools and materials

1. Tools

    a. Propane torch

    b. Tinner snips

    c. Soldering iron

    d. Hand drill and bits

2. Materials

    a. Metal can with "pop lid"

    Example: Cocoa can

    b. Steel or brass tubing ($^1/_4$" diameter)

    c. Metal disc, 8 cm in diameter

    Example: The end of a food can

    d. Metal strip, 30 cm in length, 2 cm wide

    e. Stiff wire, 15 cm in length

    f. Wood or metal block (2 cm × 20 cm × 20 cm)

    g. Miscellaneous hardware

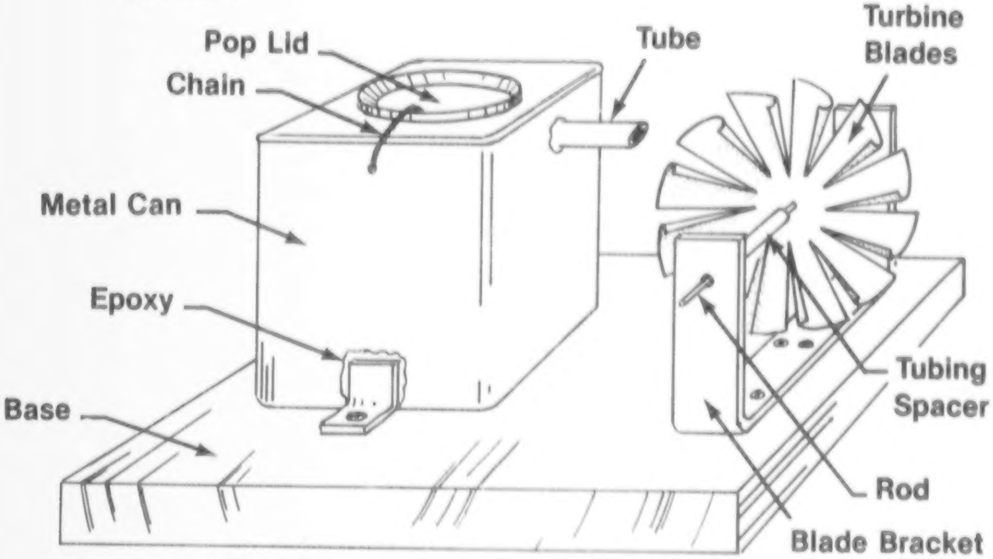
    Example: screws

    h. Expoxy cement

    i. Solder, acid core

JOB SHEET #1

FIGURE 1



B. Procedure

1. Study carefully the drawing of boiler and turbine. (Figure 1)
2. Check the lid on the boiler can to be sure it's not pressed on too tightly.

   (NOTE: The lid will act as a safety valve and pop open if the pressure in the boiler gets too high. A chain may be attached to keep the lid from flying when steam pressure builds.)
3. Scrape the can around the area where the hole will be made and tube inserted.

   (NOTE: This removes any coating that would prevent solder from sticking.)
4. Drill hole in can the size of the tubing.
5. Insert tube.
6. Solder tube to can.
7. Check nozzle for blockage.
   a. Fill boiler about one-third full of water.
   b. Heat gradually the side of the can using the flame from a propane torch until steam comes out. A bunsen burner or other source of heat is an option if the base is metal.

      (NOTE: Steam can cause severe burns. DO NOT stand directly over can while heating. If the lid should pop off, steam and hot water may splash out.)

JOB SHEET #1

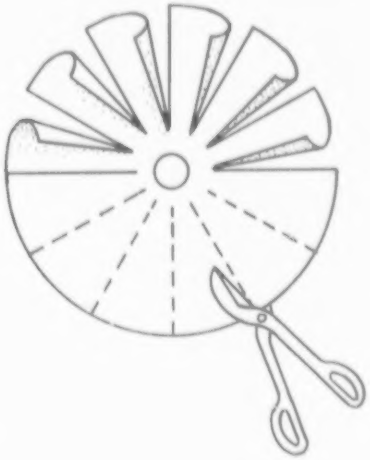
8. Set boiler aside to cool if all works properly. If not:
   a. Empty water.
   b. Cool with cold water.
   c. Clear tube.
   d. Check solder to assure weld is not broken.
   e. Repeat step 7.

   (NOTE: Stop at this point if this job sheet is to be combined with Job Sheets #2 and 3, and continue with Job Sheet #2.)

9. Drill hole in center of metal disc just large enough for rod to pass through.

10. Cut turbine blades from metal disc using tinner snips.

FIGURE 2



11. Bend blades with needlenose pliers into "scoops."

    (CAUTION: The cut edges of tin are very sharp, so handle carefully!)

12. Insert rod through turbine blades.

13. Solder rod to blade at center point.

14. Bend metal strip for blade bracket.

15. Drill holes in both ends of bracket so that rod holding turbine blades can turn freely.

JOB SHEET #1

16. Slide a short piece of tubing on either side of the shaft to keep turbine blade in line with steam nozzle.

    (NOTE: This should be a loose fit to allow free turning.)

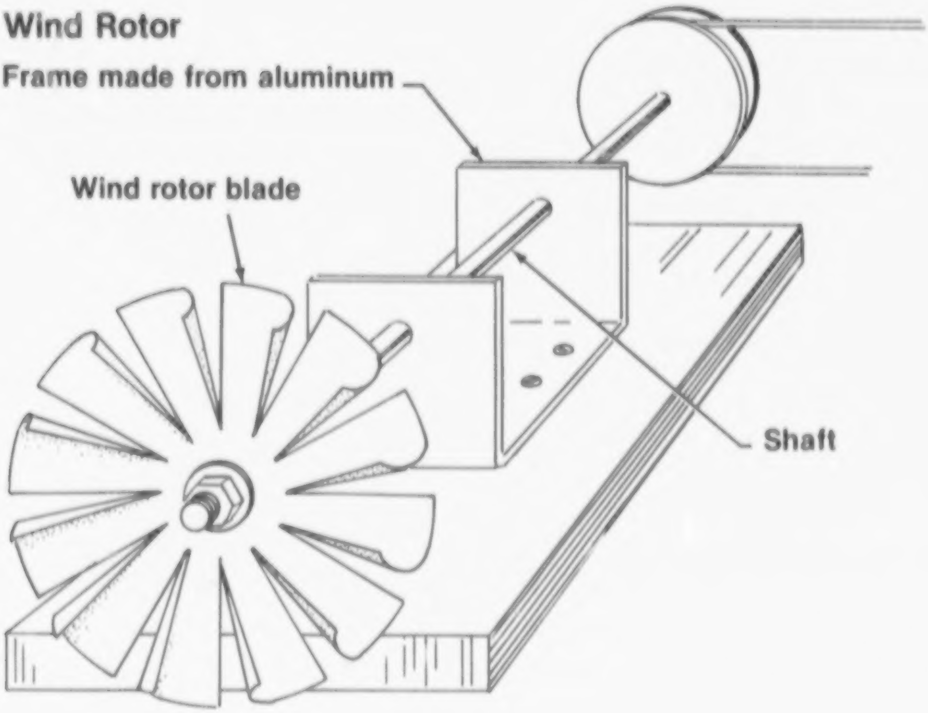
17. Mount boiler can and blade bracket to base using wood screws if base is wood or epoxy if base is metal. Boiler nozzle must be positioned so the steam produced is directed into the turbine blades. (Figure 1)

18. Test turbine.

PRINCIPLES OF ENERGY AND POWER
UNIT II

JOB SHEET #2 — CONSTRUCT A WIND ROTOR

FIGURE 1


Wind Rotor
Frame made from aluminum
Wind rotor blade
Shaft

A. Tools and materials

1. Tools

   a. Tinner snips

   b. Soldering iron

   c. Hand drill and bits

   d. Needlenose pliers

2. Materials

   a. Wood base (2 cm × 20 cm × 20 cm)

JOB SHEET #2

- b. Metal disc for rotor (the end of a food can, 8 cm)
- c. Metal rod for shaft, 5 mm diameter (all threaded rod)
- d. Miscellaneous hardware (screws, lock-nuts)
- e. Acid core solder
- f. Soldering flux
- g. Rivets
- h. Metal strip for bracket
- i. Pulley

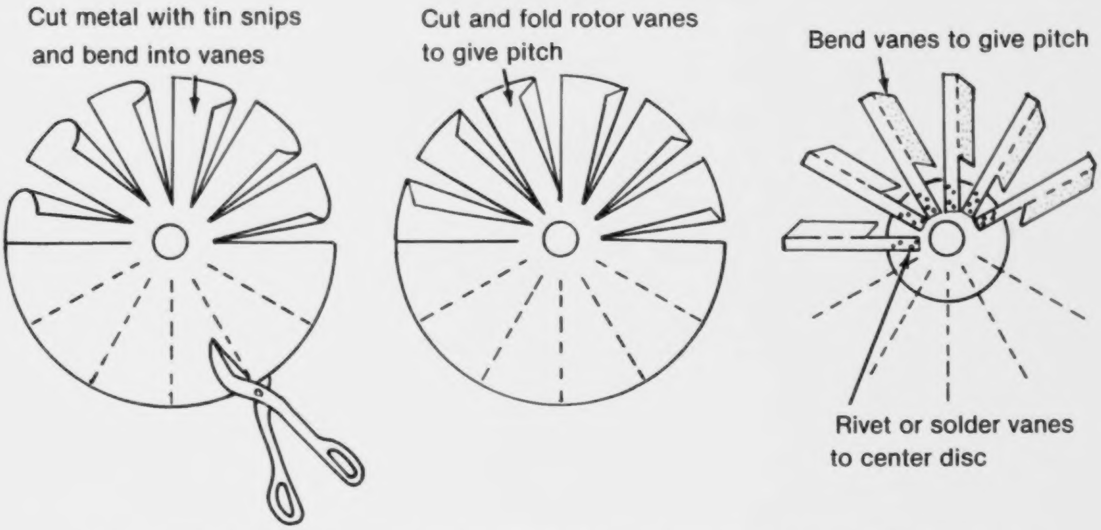
B. Procedure

1. Choose design and mark blades. (Figure 2)
2. Cut rotor blades with tinner snips.

   (CAUTION: The cut edges of tin are very sharp. Work CAREFULLY!)

FIGURE 2

Rotor Blade Designs


Cut metal with tin snips
and bend into vanes
Cut and fold rotor vanes
to give pitch
Bend vanes to give pitch
Rivet or solder vanes
to center disc

3. Bend blades with needlenose pliers or attach separate blades with rivets or solder (depending on design).

JOB SHEET #2

4. Drill hole in middle of rotor (5 mm diameter).
5. Mount rotor on shaft.
6. Place lock nut on either side of rotor to hold it to the shaft.
7. Bend metal strip for bracket.
8. Drill holes for shaft and mounting.
9. Mount rotor and shaft on bracket.
10. Mount bracket on base.
11. Mount pulley on shaft.
12. Test wind rotor outside or with a fan for a constant air supply.

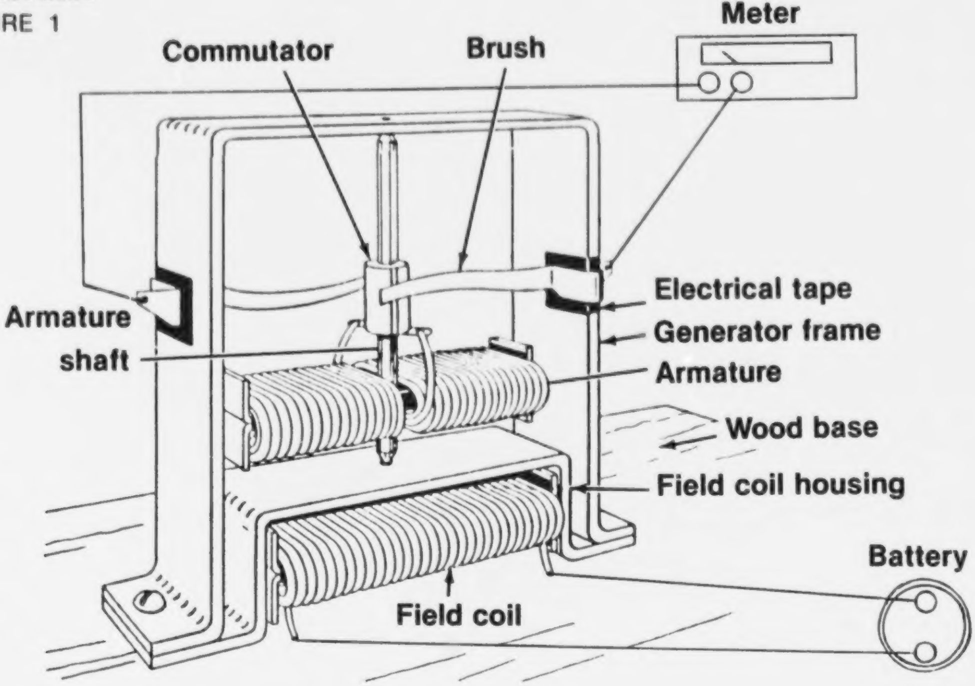
    (NOTE: Compressed air can be used if necessary.)
13. Vary blade designs to improve efficiency.
14. Check efficiency by measuring changes in rotor speed.
15. Hook up pulley to electric generator (Job Sheet #3).
16. Are you generating electricity?

    (NOTE: When the wind rotor is combined with the electric generator, additional experiments can be performed to measure voltage and amperage.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

JOB SHEET #3 — BUILD AN ELECTRIC GENERATOR

Generator
FIGURE 1


Meter
Commutator
Brush
Electrical tape
Generator frame
Armature
Armature shaft
Wood base
Field coil housing
Battery
Field coil

A. Tools and materials

1. Tools
   a. Soldering iron (may use metal base epoxy)
   b. Hand drill and bits
   c. Sheet metal tools (shear and barfold) if available
   d. Tinner snips
2. Materials
   a. Aluminum sheet (14 to 18 gauge)
   b. 16d nail
   c. #24 coated magnet wire

JOB SHEET #3

d. Copper foil

e. Copper or brass strip (6mm wide)

f. Solder — rosin core

g. Electrician's tape

h. Wood base (2 cm × 10 cm × 10 cm)

i. Round head wood screws

j. Battery

k. Household cement/epoxy

l. Galvanized sheet steel (24 to 28 gauge)

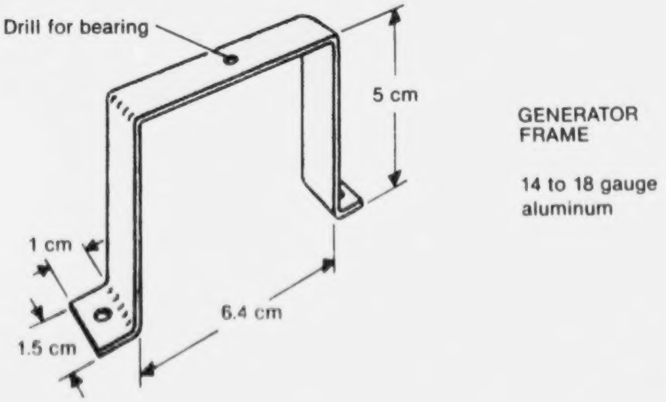
B. Procedure

1. Cut and shape metal parts as shown in the illustrations. (Figures 2-5)

   a. Bend generator frame and drill for bearing. (Figure 2)

   (NOTE: Hole for bearing should be smaller than diameter of shaft.)

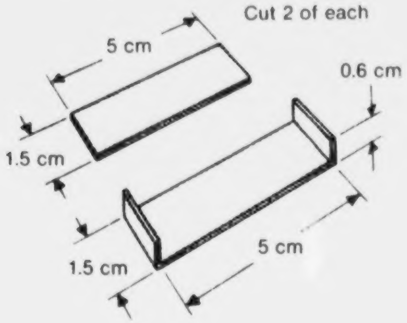
   FIGURE 2


Drill for bearing
5 cm
GENERATOR FRAME
14 to 18 gauge aluminum
1 cm
6.4 cm
1.5 cm

JOB SHEET #3

b. Cut and bend field coil core. (Figure 3)

FIGURE 3

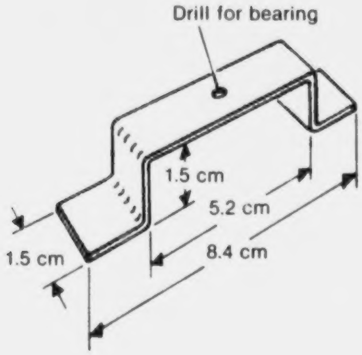

Cut 2 of each
5 cm
0.6 cm
1.5 cm
1.5 cm
5 cm

FIELD COIL CORE

24 to 28 gauge galvanized sheet iron

c. Bend field coil housing and drill for bearing. (Figure 4)

FIGURE 4

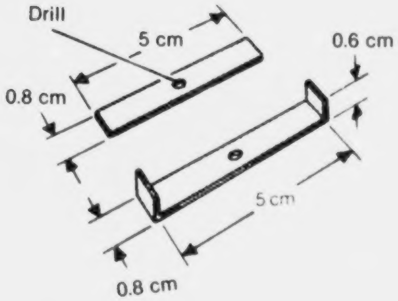

Drill for bearing
1.5 cm
5.2 cm
8.4 cm
1.5 cm

FIELD COIL HOUSING

14 to 18 gauge aluminum

d. Cut, bend, and drill armature. (Figure 5)

FIGURE 5


Drill
5 cm
0.6 cm
0.8 cm
5 cm
0.8 cm

ARMATURE

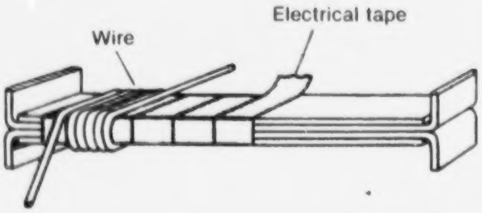
24 to 28 gauge galvanized sheet iron

Cut 2 of each

JOB SHEET #3

2. Assemble field coil. (Figure 6)

FIGURE 6



FIELD COIL

a. Remove sharp edges from all metal pieces.

b. Assemble metal pieces and wrap with electric tape.

c. Wrap five layers of enamel-coated wire over electric tape winding slowly, carefully, and in the same direction.

d. Test completed field coil by attaching a dry cell to the two ends of the wire coil and checking with a compass. Does the compass needle line up with the length of the coil? If so, proceed.

3. Assemble armature.

a. Remove sharp edges from metal pieces.

b. Assemble pieces and wrap with electric tape.

c. Place shaft in center of assembly.

d. Wrap armature beginning at the center, leaving several centimeters of wire for later use.

e. Wind carefully from the shaft to the end and back again to the center.

f. Repeat, placing four layers of wire on the one side of the shaft.

g. Cross over to the other side of the shaft without breaking the wire, and wind, going from center to end.

h. Repeat, adding four layers of wire.

i. Leave 2 cm of wire at the end for later use.

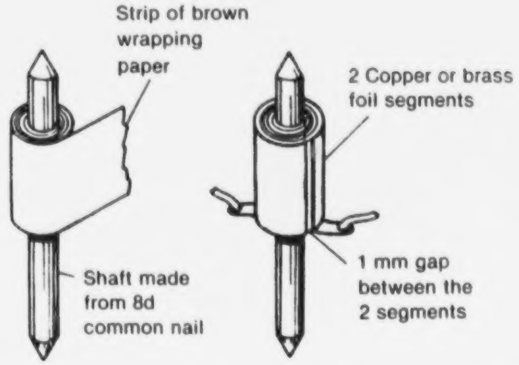
j. Test armature.

(NOTE: Step 2d.)

JOB SHEET #3

4. Make commutator. (Figure 7)

FIGURE 7


Strip of brown wrapping paper
2 Copper or brass foil segments
Shaft made from 8d common nail
1 mm gap between the 2 segments

COMMUTATOR

a. Wrap brown craft paper (1 cm wide) around the shaft until a cylinder about 7 mm in diameter is formed. Coat with household cement while wrapping.

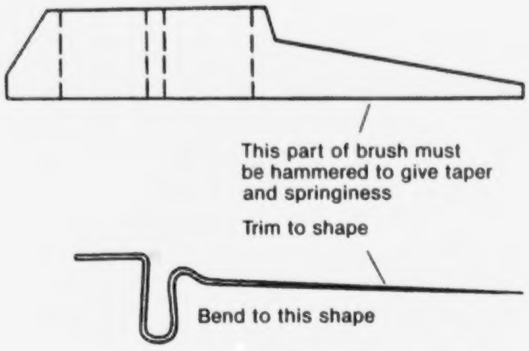
(NOTE: This prevents paper from slipping and provides a firm surface for the brushes to run on.)

b. When the glue dries, add commutator segments made from copper foil shaped around a pencil.

c. Leave tabs where wires from the coil can be soldered.

5. Make brushes. (Figure 8)

FIGURE 8


This part of brush must be hammered to give taper and springiness
Trim to shape
Bend to this shape

BRUSHES

JOB SHEET #3

   a. Cut 2 brushes from 22 or 24 gauge copper or brass according to pattern.

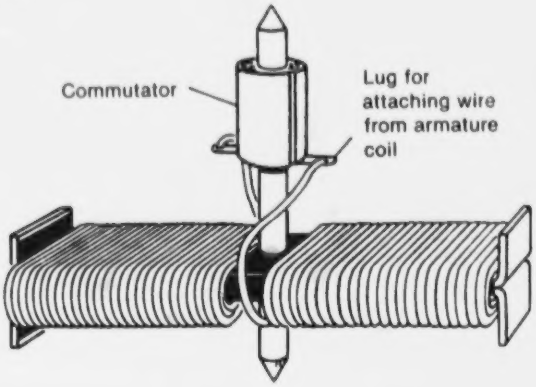
   b. Hammer the tip of the brush to give taper and springiness.

   c. Trim brushes to shape.

   d. Bend brushes to shape.

6. Assemble armature assembly. (Figure 9)

FIGURE 9



   a. Place the shaft of the commutator in the center of the armature.

   b. Shaft must fit snugly. If it is necessary, solder or epoxy shaft to armature to prevent slippage.

   c. Remove enamel coating from ends of wires.

   d. Solder wires to commutator tabs.

7. Attach field coil to field coil housing. (See Figure 1)

8. Attach armature and generator frame to field coil housing.

9. Fasten total assembly to base. Spin the armature. If binding occurs, free pressure by bending frame so the top is moved off the shaft.

10. Clip brushes onto frame, placing electrical tape underneath for insulation, so that brushes rub lightly on commutator segments.

11. Connect field coil wires to dry cell.

12. Connect leads of an ammeter to brushes.

JOB SHEET #3

13. Is there any generation of electricity?

14. Spin the armature.

15. Why does electricity flow only when armature spins?

    (NOTE: Additional experiments can be performed by attaching a pulley above the commutator on the generator and, using a rubber band as a belt, attach to pulley on the wind turbine or steam turbine to produce electricity. Compressed air can be used instead of steam as a source of power. Measure the voltage and amperage produced by the generator.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

PRACTICAL TEST
JOB SHEET #1 — BUILD AND TEST A STEAM TURBINE

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask you instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Studied drawings of boiler and turbine.	______	______
3. Scraped can around hole.	______	______
4. Inserted tube and soldered to can.	______	______
5. Checked to see that nozzle was not blocked.	______	______
6. Set boiler aside to cool.	______	______
7. Cut turbine blades.	______	______
8. Bent blades with needle nose pliers.	______	______
9. Bent metal strips for blade bracket.	______	______
10. Drilled holes in bracket for turbine rod.	______	______
11. Soldered rod to turbine blades.	______	______
12. Assembled turbine blades and rod in bracket.	______	______
13. Drilled holes for mounting boiler and turbine brackets.	______	______
14. Mounted boiler can and turbine on wood block.	______	______
15. Checked in/put away tools and materials.	______	______
16. Cleaned the work area.	______	______
17. Used proper tools correctly.	______	______
18. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
19. Practiced safety rules throughout procedure.	______	______
20. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Boiler	Cleaned and Soldered Neatly	Irregular Solder	Leakage Around Soldered Joint	Enlarged Hole/ Improperly Soldered
	4	3	2	1
Turbine blades	Cut Accurately/ Proper Curve	Out of Round	Out of Balance	Redo
	4	3	2	1
Bracket	Properly Bent/ Positioned Correctly	Improperly Mounted	Improperly Aligned Holes	Redo
	4	3	2	1
Base	Meets Requirements	Too Thick	Too Thin	Redo
	4	3	2	1
Steam Turbine	Operates Correctly	Needs Minor Adjustment	Needs Major Adjustment	Redo

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

PRACTICAL TEST
JOB SHEET #2 — CONSTRUCT A WIND ROTOR

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask you instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Made rotor from metal disc.	______	______
3. Drilled hole in center of rotor and mounted on shaft.	______	______
4. Placed lock nut on both sides of rotor.	______	______
5. Bent metal strip for bracket, drilled holes.	______	______
6. Mounted bracket, rotor, and shaft on base.	______	______
7. Tested rotor.	______	______
8. Checked in/put away tools and materials.	______	______
9. Cleaned the work area.	______	______
10. Used proper tools correctly.	______	______
11. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
12. Practiced safety rules throughout procedure.	______	______
13. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Rotor	Cut Accurately/ Proper Curve	Out of Round	Out of Balance	Redo
	4	3	2	1
Shaft	Correct Length/ Spins Freely	Too Long	Too Short	Redo
	4	3	2	1
Bracket	Properly Bent/ Positioned Correctly	Improperly Mounted	Improperly Aligned Holes	Redo
	4	3	2	1
Base	Meets Requirements	Too Thick	Too Thin	Redo
	4	3	2	1
Wind Rotor	Operates Correctly	Needs Minor Adjustment	Needs Major Adjustment	Redo

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

PRACTICAL TEST
JOB SHEET #3 — BUILD AN ELECTRIC GENERATOR

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask you instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Cut and shaped metal parts.	______	______
3. Assembled field coil.	______	______
4. Wrapped wire around core.	______	______
5. Tested completed field core.	______	______
6. Assembled armature.	______	______
7. Wound armature.	______	______
8. Tested armature.	______	______
9. Made commutator.	______	______
10. Made brushes.	______	______
11. Assembled armature assembly.	______	______
12. Assembled field core, field core housing, generator frame, and armature.	______	______
13. Connected brushes to ammeter.	______	______
14. Connected field core to dry cell.	______	______
15. Tested generator.	______	______
16. Checked in/put away tools and materials.	______	______
17. Cleaned the work area.	______	______
18. Used proper tools correctly.	______	______
19. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
20. Practiced safety rules throughout procedure.	______	______
21. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Metal Parts	Meet Specifications	Minor Adjustment	Major Adjustment	Replace Part
	4	3	2	1
Field Coil	Operable	Minor Adjustment	Major Adjustment	Non-operable/ Redo
	4	3	2	1
Armature	Operable	Minor Adjustment	Major Adjustment	Non-operable/ Redo
	4	3	2	1
Motor	Operable	Minor Adjustment	Major Adjustment	Non-operable Redo

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

PRINCIPLES OF ENERGY AND POWER
UNIT II

NAME ______________________________ SCORE ______________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. The resistance to motion produced when two objects rub against each other

_____b. A meter that can measure different values such as voltage, current, and resistance

_____c. An instrument used to measure the amount of voltage in a circuit

_____d. An instrument used to measure the amount of current in a circuit

_____e. The process of changing energy from one of its six forms into another

_____f. The percentage of available energy converted into usable energy

_____g. Unit of measure for electrical current

_____h. An instrument used to measure resistance to current flow

_____i. Standard unit of measuring resistance to current flow

_____j. Energy in motion

_____k. The amount of energy in the universe is fixed; it cannot be created or destroyed

1. Ammeter
2. Ampere
3. Efficiency
4. Voltmeter
5. Energy conversion
6. Friction
7. Kinetic energy
8. Law of conservation of energy
9. Multimeter
10. Ohm
11. Ohmmeter
12. Potential energy

2. List two types of power systems.

a. ____

b. ____

TEST

3. Arrange in order the stages of power systems by placing the correct sequence numbers (1-4) in the appropriate blanks.

______a. Conversion and control

______b. Output

______c. Input

______d. Transmission and control

4. Distinguish between the basic measuring systems by writing "English" or "Metric" in front of the appropriate definition.

____________a. Measuring system used by most of the industrial countries of the world; basic units are the meter, the liter, and degree Celsius

____________b. Measuring system traditionally used in the United States; basic units are the foot, the pound, and degree Fahrenheit

5. Complete a chart of basic units of measurement by filling in the missing terms.

Measurement	Metric Units	English Units
a. ______________	millimeters centimeters meters kilometers	inches feet yards miles
b. Weight	grams kilograms metric tons	______________ ______________ ______________
c. ______________	milliliters liters cubic centimeters	ounces cups pints quarts gallons
d. Area	square centimeters square meters	________ ________ ________ ________
e. Temperature	______________	degrees Fahrenheit
f. Speed	kilometers per hour	______ ______ ______

TEST

	Measurement	Metric Units	English Units
g.	________________	newtons	pounds
h.	Torque	newton-meters	________-________
i.	________________	pascals	pounds per square inch (psi) inches of mercury

6. Use the appropriate prefixes of milli-, kilo-, and centi- for changing metric base units.

   a. 1000 meters = ____________ meters

   b. 1/100 of a gram = ____________ gram

   c. 1/1000th of a liter = ____________ liter

7. State the units for measuring energy and power.

		Metric Unit	English Unit
a.	Mechanical energy	______________	foot-pounds
b.	Mechanical power	watts	______________
c.	Electrical energy	______________	joules
d.	Electrical power	watts	______________

8. Match terms related to measuring mechanical power on the right with the correct definitions.

_____a. Measurement of useful motion (mechanical energy)

_____b. Work per unit of time

_____c. Any push or pull on an object

_____d. Turning or twisting effort

_____e. Force per unit of area

1. Power
2. Ohms
3. Force
4. Pressure
5. Torque
6. Work

TEST

9. Calculate the following problems using the formula for work.

   Work = force × distance

   a. How much work is accomplished if it takes 60 pounds of force to move a 200 pound box 50 feet?

   ____

   b. One man pushes a 250 pound weight 100 feet along a warehouse floor. The force necessary to slide the weight is 75 pounds. How much work is accomplished?

   ____

10. Calculate the following problems using the formula for horsepower.

$$HP = \frac{\text{Force} \times \text{Distance}}{\text{Time (sec)} \times 550}$$

   a. How much horsepower is produced if it takes 20 seconds to slide a 200-pound box a distance of 20 feet using 55 pounds force?

   ____________________ horsepower

   b. How much horsepower is needed to move a 250-pound box a distance of 10 feet using 100 pounds of force in 10 seconds?

   ____________________ horsepower

11. Calculate the following problems using the formula for torque:

   Torque = Force × Radius (in feet)

   a. If 10 pounds is applied to a wrench 6 inches long, what is the torque?

   ____

   b. What is the torque, if 20 pounds of force is applied to a wrench 1 ft. long?

   ____

12. Match the terms related to measuring electrical power on the right with the correct definitions.

   _____a. The rate at which current flows through a conductor

   _____b. The opposition to current flow through a conductor

   _____c. The pressure pushing the current through the conductor

   1. Voltage
   2. Amperage
   3. Resistance

TEST

13. State Ohm's law in letter formula for calculating voltage, current, and resistance.

    a. For calculating voltage, ______ = ____________

    b. For calculating amperage, ______ = ____________

    c. For calculating resistance, ______ = ____________

14. Draw Ohm's law in triangle expression.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

15. Solve problems using Ohm's law. (Assignment Sheet #4)

16. Demonstrate the ability to:

    a. Build and test a simple, low pressure steam turbine. (Job Sheet #1)

    b. Construct a wind rotor. (Job Sheet #2)

    c. Build an electric generator. (Job Sheet #3)

PRINCIPLES OF ENERGY AND POWER
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 9
   c. 4
   d. 1
   e. 5
   f. 3
   g. 2
   h. 11
   i. 10
   j. 7
   k. 8

2. Any two of the following:
   a. Mechanical power
   b. Electrical power
   c. Fluid power

3. a. 2
   b. 4
   c. 1
   d. 3

4. a. Metric
   b. English

5. a. Length
   b. Ounces, pounds, tons
   c. Volume
   d. Square inches, square feet, square yards
   e. Degrees Celsuis
   f. Miles per hour
   g. Force
   h. Pound-feet
   i. Pressure

6. a. Kilo
   b. Centi
   c. Milli

7. a. Joules
   b. Horsepower
   c. Joules
   d. Watts

8. a. 6
   b. 1
   c. 3
   d. 5
   e. 4

9. a. 3000 foot-pounds
   b. 7500 foot-pounds

ANSWERS TO TEST

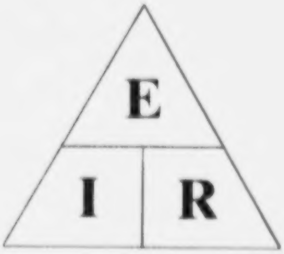
10. a. 0.1 horsepower
    b. 0.18 horsepower

11. a. 5 pound-feet
    b. 20 pound-feet

12. a. 2
    b. 3
    c. 1

13. a. E = I × R
    b. I = E/R
    c. R = E/I

14.



15. Evaluated to the satisfaction of the instructor

16. Performance skills evaluated to the satisfaction of the instructor

POWER PRODUCTION AND CONVERSION
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between types of internal and external combustion engines, check engine components for wear, and disassemble and reassemble a four-stroke cycle, one cylinder engine. Competencies will be demonstrated by completing the assignment sheet, job sheets, and unit tests with a minimum of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to power production and conversion with the correct definitions.
2. Distinguish between the types of conversions.
3. Select true statements concerning common direct conversion systems.
4. Match common methods of converting energy with the correct definitions.
5. Select true statements concerning the conversion of electrical power.
6. Distinguish between classifications of engines.
7. Complete statements concerning types of external combustion engines.
8. Match types of internal combustion engines with the correct descriptions.
9. Distinguish between the operations of two-stroke and four-stroke cycle gasoline engines.
10. Identify parts of a basic internal combustion engine.

OBJECTIVE SHEET

11. Match the systems of an engine with the correct functions and parts.

12. Complete statements concerning safety rules to follow when working with engines.

13. Check engine components for wear. (Assignment Sheet #1)

14. Demonstrate the ability to:

    a. Disassemble and reassemble a four cycle, one cylinder engine. (Job Sheet #1)

    b. Construct a solar battery. (Job Sheet #2)

POWER PRODUCTION AND CONVERSION
UNIT III

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparency to enhance the information as needed.)

G. Provide students with job sheet.

H. Discuss and demonstrate the procedure outlined in the job sheet.

I. Integrate the following activities throughout the teaching of this unit:

1. Obtain manuals from manufacturers of small gas engines for a four cycle, one cylinder engine (Briggs & Stratton, etc.).

2. Obtain four cycle, one cylinder engines that can be used for assembly and disassembly.

   (NOTE: New engines can be obtained by writing major manufacturers on official school stationery stating reasons for request.)

3. Calculate torque on a small gas engine using a torque wrench.

4. Students can substitute scale model engines for the assembly and disassembly of small gas engines in Assignment Sheet #1 and Job Sheet #1.

5. Explain sub-systems of an automobile using a real automobile as a teaching aid.

6. Use a dynamometer to test a small engine's horsepower.

7. Show examples of fuel cells, solar cells, small batteries, and automobile batteries.

8. Have students build other solar projects such as collectors and heaters in addition to Job Sheet #2.

SUGGESTED ACTIVITIES

9. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Bohn, Ralph C. and Angus J. MacDonald. *Power: Mechanics of Energy Control.* Bloomington, Illinois: McKnight Publishing Co, 1983.

B. Bohn, Ralph C., et. al. *Energy, Power, and Transportation Technology.* Peoria, Illinois: Bennett & McKnight, 1986.

C. Grannis, Gary E. *Modern Power Mechanics.* Indianapolis, Indiana: Bobbs-Merrill, 1979.

D. Smith, Howard Bud, ed. *Exploring Energy: Sources/Applications/Alternatives.* South Holland, Illinois: Goodheart-Willcox Company, Inc., 1985.

E. Walker, John R. *Exploring Power Technology: Basic Fundamentals.* South Holland, Illinois: Goodheart-Willcox Co., Inc., 1981.

SUGGESTED SUPPLEMENTAL RESOURCES

Films:

A. *The Atom: A Closer Look* (30 min, color) Disney, 1982; #10543; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

B. *Backyard Alternative Energy* (26 min, color) Brumfield Kirby, 1978; #03751; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

C. *Energy: New Sources* (20 min, color) Churchill, 1974; #08241; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

D. *Energy from the Sun (2nd Edition)* (18 min, color) EBE, 1980; #10031; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

E. *Energy in Perspective* (21 min, color) BP North America, 1976; #02218; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

SUGGESTED SUPPLEMENTAL RESOURCES

F. *Fusion, the Ultimate Fire* (14 min, color) BFA, 1976; #01434; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

G. *Geothermal Power (2nd Edition)* (16 min, color) AIMS, 1982; #10392; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

H. *Geysers and Hot Springs (Revised)* (10 min, color) Barr Films, 1969; #08619; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

I. *Gusts of Power* (14 min, color) National AV Center, 1979; #02543; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

J. *Modern Engines and Energy Conversion (Revised)* (12 min, color) Centron, 1978; #04837, to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

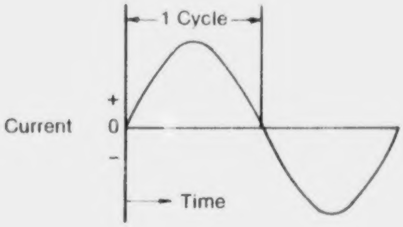
K. *Oil — From Fossil to Flame* (13 min., color) Centron 1976; to order phone (608) 262-1644; or write Bureau of Audio Visual Instruction, P.O. Box 2093, Madison, Wisconsin 53701-2093.

POWER PRODUCTION AND CONVERSION
UNIT III

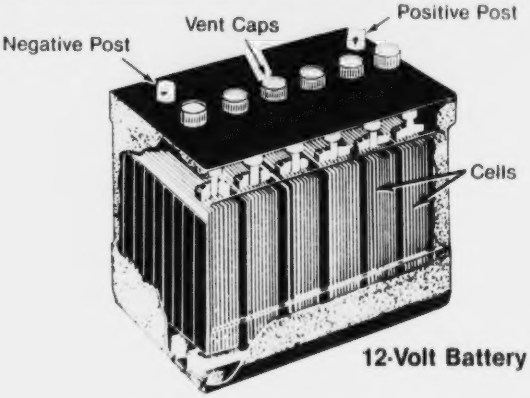
INFORMATION SHEET

I. **Terms and definitions**

A. Alternating current (AC) — Current that alternately changes direction

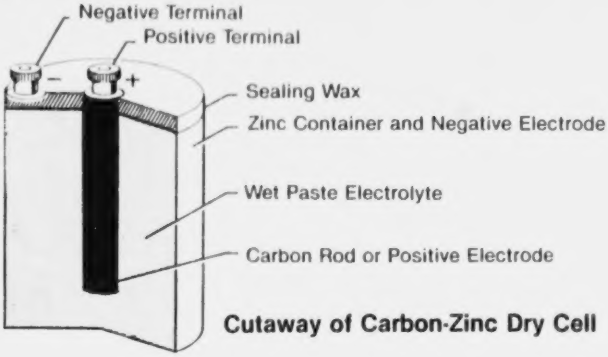


B. Battery — A connected group of cells storing an electrical charge and capable of furnishing a current


Negative Post
Vent Caps
Positive Post
Cells

12-Volt Battery Containing 6 Cells in Series

C. Cell — A container that holds electrodes and electrolytes for generating electricity by chemical action

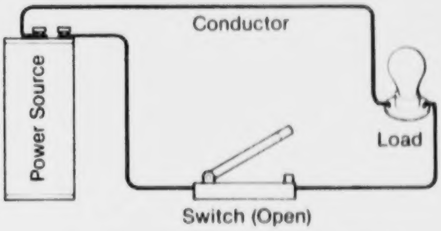

Negative Terminal
Positive Terminal
–
+
Sealing Wax
Zinc Container and Negative Electrode
Wet Paste Electrolyte
Carbon Rod or Positive Electrode

Cutaway of Carbon-Zinc Dry Cell

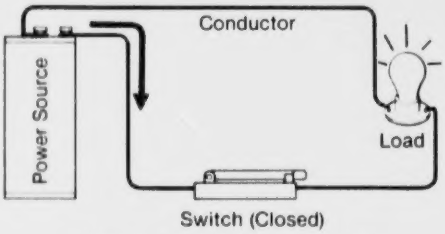
INFORMATION SHEET

D. Circuit — The complete path of an electric current

(NOTE: A circuit must have 4 parts — A source of power, a conductor, a switch, and a load. The following illustrations show these parts in an open circuit and in a closed circuit. An open circuit is usually broken by an open switch or a disconnected wire. A closed circuit is required for current flow.)



Simple Circuit (Open Circuit)



Simple Circuit (Closed Circuit)

E. Combustion — Process of burning

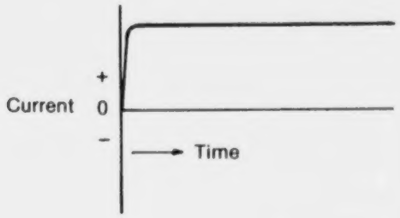
F. Compression — Reducing the volume of air or air-fuel mixture by pressure

G. Conductor — A substance capable of transmitting electricity easily

Examples: Silver, copper, aluminum

H. Current — The movement of electrons through a conductor

I. Direct current (DC) — Current that flows through a conductor in only one direction



J. Insulator — A substance that does not allow the transmitting of electricity

Examples: Glass, dry wood, rubber

K. Reciprocating motion — Back and forth movement

L. Rotary motion — Circular motion

M. Stroke — The movement of a piston from one end of a cylinder to the other

N. Thrust — A forward push or force

INFORMATION SHEET

II. Types of conversions

A. Direct conversion — When energy is used after only one conversion

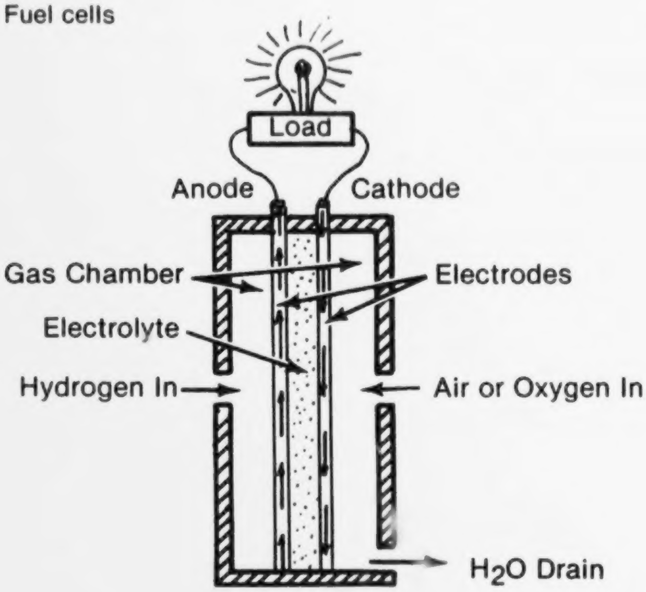
Examples: Solar cells convert sunlight directly into electricity, quartz or similar crystals can convert mechanical energy into electrical energy (known as the piezo-electrical effect)

B. Indirect conversion — When several conversions must take place before the energy is in the right form to do work

Example: Automobile engines convert fuel (chemical energy) into heat energy for combustion then into mechanical engines to move gears and wheels; may also be converted to electrical energy and then to light energy by headlights

III. Common direct conversion systems

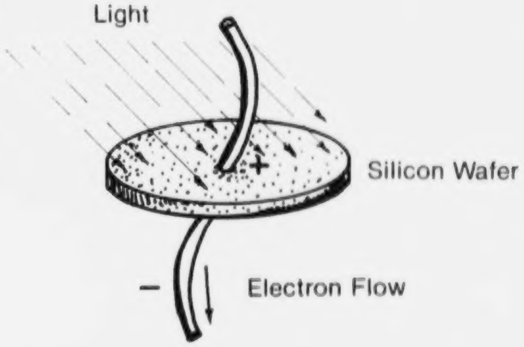
A. Fuel cells



1. Convert chemical energy (fuel) directly to electric energy.
2. Will provide a continuous flow of electric current as long as the fuel supply is continuous.
3. Differ from an ordinary battery in that the electrodes are **not** consumed as they are in a battery.
4. The most successful fuel cell is the Hydrox cell which is fueled by liquid hydrogen which mixes with liquid oxygen.

INFORMATION SHEET

B. Solar cells



1. Are crystals (selenium or silicon) that convert solar energy directly into electricity.
2. Are relatively expensive and are not very efficient (about 11%).
3. Are most useful where weight is a factor and voltage demands are low.

   Example: Solar calculators, solar light meters for cameras

IV. **Common methods of converting energy (indirect conversion)**

A. Generators — Convert mechanical (rotary) energy into electrical energy

B. Engines — Convert any form of energy into mechanical energy

Examples: Gasoline engine, steam engine, diesel engine

C. Turbines — Rotating devices driven by wind, steam, or water that are used to drive electric generators

D. Motors — An electrical- or fluid-operated device that converts energy to mechanical energy

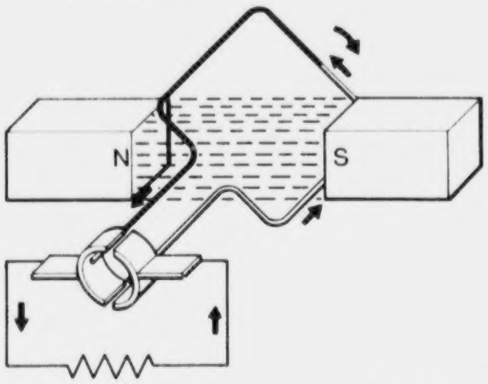
V. **Conversion of electrical power**

A. Generators are used to convert mechanical energy to electrical energy.

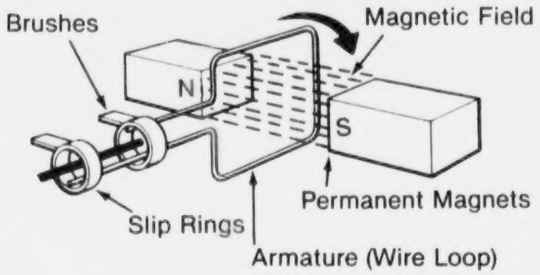
INFORMATION SHEET

B. There are two types of generators.

1. Direct current (DC) generators — Produce electric current that flows in only one direction



2. Alternating current generators — Produce electric current that reverses the direction of current flow many times each second.



(NOTE: Alternating current is more widely used than direct current because it can be readily changed to high voltages for transmission over long distances by transformers.)

C. Generators vary in size. Large generators are used to provide electric power for cities.

D. Large generators are usually powered by steam turbines or hydroelectric power.

(NOTE: About 80% of the electricity used in the United States is produced by steam turbine powered generators.)

INFORMATION SHEET

VI. **Classifications of engines** (Transparency 1)

A. Internal combustion engine

Examples: Gasoline engine, diesel engine, jet engine

1. Produces power by the intermittent (not continuous) combustion of a fuel/air mixture in a combustion chamber in the engine.

2. Expanding hot gases in chamber produce work by pushing a piston, turning a turbine, or producing reaction propulsion (as in a rocket engine).

B. External combustion engine

Examples: Steam engine, steam turbine, Stirling engine

1. Produces power by the continuous combustion of a fuel source burned outside of the engine.

2. Burning fuel converts a working fluid (usually water) into a high-pressure vapor (steam) which is then delivered to the engine.

VII. **Types of external combustion engines**

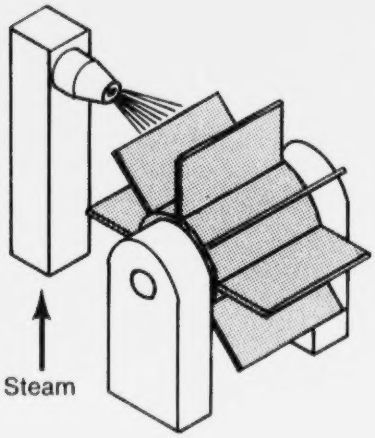
A. Steam engines (Transparency 2)

1. Operation — A fuel source is burned and heats a boiler. Heat converts water to steam. Steam travels through pipes to the engine. Steam pressure inside engine drives pistons and produces motion.

2. Possible energy sources for steam engines include all fossil fuels as well as nuclear, radiant, and geothermal energy.

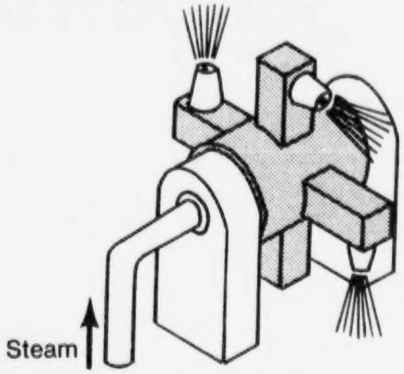
B. Steam turbines

1. Impulse type — High-pressure steam is directed against the turbine blades which causes the turbine wheel to rotate at high speeds.



INFORMATION SHEET

2. Reaction type — Steam escapes from nozzle on the turbine wheel; the action of the escaping steam creates an opposite reaction in the wheel that produces rotation.



C. Stirling engine (Transparency 2)

(NOTE: This engine was invented by Robert Stirling in 1816.)

1. Operation — Heat is applied to the outside of the engine cylinder which causes the gas inside the cylinder (usually hydrogen or helium) to expand. This increases the pressure which causes the piston to move down. Then the gas in the cylinder is cooled by an outside cooler which causes the gas to contract, pressure drops, and piston moves back up.

   (NOTE: Modern Stirling engines use two pistons instead of one, the compression piston and the expansion piston.)

2. Potential and problems — Are more fuel-efficient and powerful than common internal combustion engines. Are hard to keep cool, and the working gases (hydrogen and helium) are difficult to contain at their high pressures. Leaks of the gas can be safety hazards since they are highly flammable.

VIII. **Types of internal combustion engines** (Transparencies 3 and 4)

A. Gasoline (piston) engines (Transparency 3)

1. Produce reciprocating motion by drawing a fuel-air mixture into a closed chamber (cylinder), compressing the mixture, and igniting it which creates pressure to drive a piston; cycle then repeats.

2. Cycle has four actions — Intake, compression, combustion (power), and exhaust.

INFORMATION SHEET

3. There are two basic types:

    a. 2-stroke cycle engine — Piston moves 2 strokes to complete a cycle.

    b. 4-stroke cycle engine — Piston moves 4 strokes to complete a cycle.

B. Diesel engines (Transparency 3)

1. Are similar to gasoline engines in that they have cylinders and pistons and burn a liquid fuel.

2. Are different from gasoline engines in that the air and fuel is mixed inside the cylinder, diesel fuel is used instead of gasoline, and there is no electrical spark to ignite the fuel. Ignition depends on the temperature and pressure of the fuel vapors.

C. Rotary engines (Transparency 3)

(NOTE: The rotary engine is sometimes referred to as the Wankel engine named for its inventor.)

1. Produce circular motion through a triangular-shaped rotor which spins inside a chamber (instead of a piston in a cylinder).

    a. The rotor has three equal faces and three working chambers.

    b. Each is separated in timing from the other faces and each provides a power impulse during one revolution of the rotor.

2. Produces three power strokes for every rotor revolution.

3. Are smaller and quieter than gasoline and diesel engines, but have low fuel efficiency and short seal life.

D. Jet and rocket engines — Produce linear motion through jet propulsion based on Newton's Third Law of Motion (For every action there is an equal and opposite reaction). The rearward expulsion of hot gases (force) creates an opposite reaction which propels the craft forward (thrust).

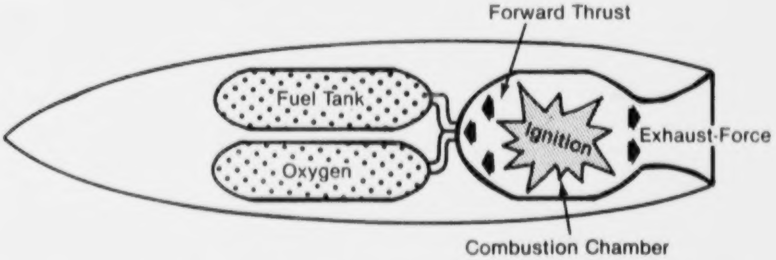
1. Jet engines (Transparency 4)

    a. Draw their air for combustion from the outside atmosphere. (Therefore, they cannot be used in space where there is no air.)

    b. Common types of jet engines include turbojet, ramjet, turbofan, and turboprop engines.

INFORMATION SHEET

2. Rocket engines (Transparency 4)
    a. Must carry their own supplies of oxygen. (Therefore, they can operate in space.)
    b. The two types of rocket engines are liquid propellant (fuel and oxygen) and solid propellent.



IX. **Operation of two-stroke and four-stroke cycle gasoline engines** (Transparency 5)

(NOTE: The number of strokes refers to the number of times the piston moves up and down in the cylinder to complete one cycle of operation. Two-stroke cycle engines are commonly called two cycle engines, and four-stroke cycle engines are commonly called four cycle engines.)

A. Two-stroke cycle engines
    1. Compression stroke (intake and compression)
        a. When piston is at the bottom position (BDC), fuel-air mixture enters cylinder through ports in cylinder wall.
        b. Piston moves up cylinder and compresses fuel-air mixture.
    2. Power stroke (combustion and exhaust)
        a. Compressed fuel-air mixture is ignited. Pressure from expanding gases forces the piston downward.
        b. Exhaust gases are forced out the exhaust ports of the cylinder.

B. Four-stroke cycle engines
    1. Intake stroke
        a. Cycle starts with piston at uppermost position in cylinder (TDC) with intake valve open and exhaust valve closed.
        b. As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor.
        c. When the piston reaches the bottom of the cylinder (BDC), the intake valve closes.

INFORMATION SHEET

2. Compression stroke

   a. Air-fuel mixture is compressed tightly as the piston moves up the cylinder.

   b. Compression of the fuel creates heat which prepares the fuel for instant ignition.

3. Power stroke

   a. As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture.

   b. Burning gases expand very rapidly and force the piston down the cylinder.

4. Exhaust stroke

   a. As the piston reaches the bottom of the cylinder on power stroke, the exhaust valve opens.

   b. Piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold.

   (NOTE: The complete cycle takes two rotations of the crankshaft or 720 degrees of rotation. The crankshaft converts the reciprocating motion of the piston into rotary motion to operate the gears.)

X. **Basic internal combustion engine parts** (Transparency 6)

A. Cylinder block — Cylinder (middle part of engine) and crankcase (bottom part of engine)

B. Cylinder head — Top part of engine bolted to cylinder block

C. Piston — Moves up and down in cylinder

D. Connecting rod — Connects piston to crankshaft

E. Crankshaft — Provides mechanical power to run the engine

F. Camshaft — Shaft which contains lobes or cams to operate engine valves

G. Valves — Devices for alternately opening and closing a passage (such as for exhaust and intake)

H. Valve spring — Spring attached to a valve to return it to the seat

I. Valve lifter or tappet — Push rod or plunger used to transfer motion between the cam and the valve on an engine

INFORMATION SHEET

XI. **Systems of an engine**

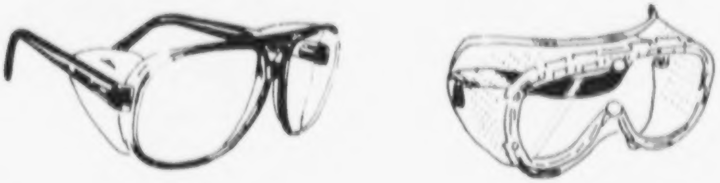
- A. Mechanical system
  - 1. Function — Develops up-and-down motion and converts it into useful rotary motion
  - 2. Parts involved — Cylinder block and head, piston, connecting rod, crankshaft, camshaft, valves
- B. Lubrication system
  - 1. Function — Lubricates (oils) engine parts to reduce friction and wear
  - 2. Parts involved — Oil pump and valves

    (NOTE: For a two-stroke engine the oil is mixed with the fuel before filling the fuel tank. Additional parts are not involved.)
- C. Cooling system
  - 1. Function — Removes excess heat from the engine
  - 2. Parts involved — Cylinder block and head has fins to release heat when air cooled or a water jacket and pump when water cooled
- D. Fuel system
  - 1. Function — Mixes air and fuel properly and delivers the mixture to the combustion chamber
  - 2. Parts involved — Air cleaner, fuel supply tank, valve, oil filter, carburetor (mixes air and fuel for combustion), governor (evens out changes in engine speed)
- E. Ignition system
  - 1. Function — Produces the spark that ignites the fuel
  - 2. Parts involved (depending on type of system) — Armature, magnets, breaker points, condenser, spark plug, battery
- F. Starting system
  - 1. Function — Sets the engine in motion
  - 2. Parts involved — Manual or electric starters

INFORMATION SHEET

XII. **Safety rules when working with engines** (Transparency 7)

A. Wear safety glasses or goggles at all times. Remember that your eyes can't be replaced. Protect them.

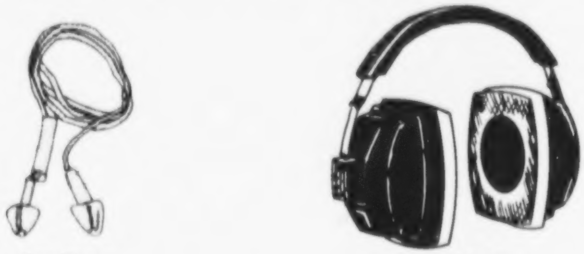


Safety Glasses
(with Sideshields)

Safety Goggles
(Perforated Frames)

Eye Protection

B. Wear approved ear protectors while working with running engines. Some are very noisy and can permanently damage your hearing.



Ear Plugs

Ear Muffs

Hearing Protection

C. Store fuel in approved safety cans in the storage areas designated by your instructor.

D. Do not inhale fumes from fuel or solvent containers. The fumes can seriously damage your lungs.

E. Have adequate ventilation when running engines, or where fumes may be a hazard.

F. Keep all flammable liquids away from fire, heat sources, and sparks which could ignite the liquid.

G. Wash your hands thoroughly if fuel splashes on them. It is very harsh and usually contains additives that are poisonous when absorbed through the skin.

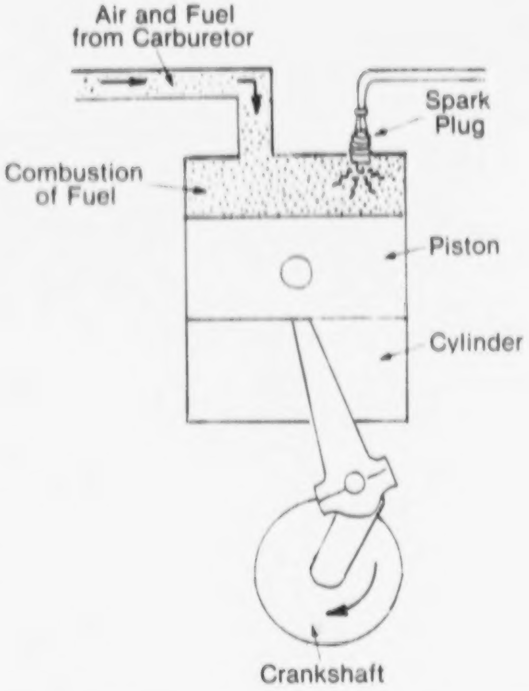
H. Never use fuel to clean parts; only use cleaning solvents.

I. Do not pour fuel into a hot or running engine fuel tank.

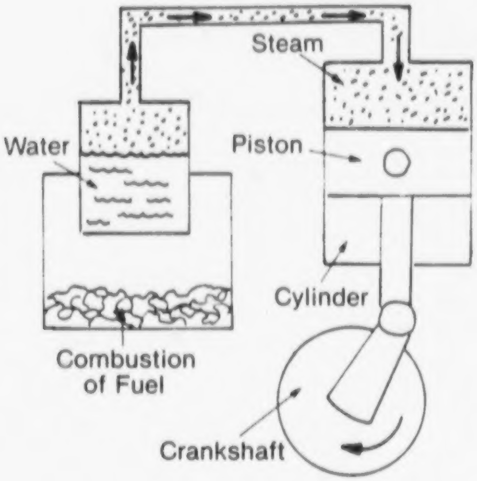
J. Wipe up any gasoline spills immediately.

K. Be careful when handling an engine battery. It contains acid which can ruin your clothes, burn your skin, and blind you if it gets in your eyes.

Classifications of Engines


Air and Fuel from Carburetor
Spark Plug
Combustion of Fuel
Piston
Cylinder
Crankshaft

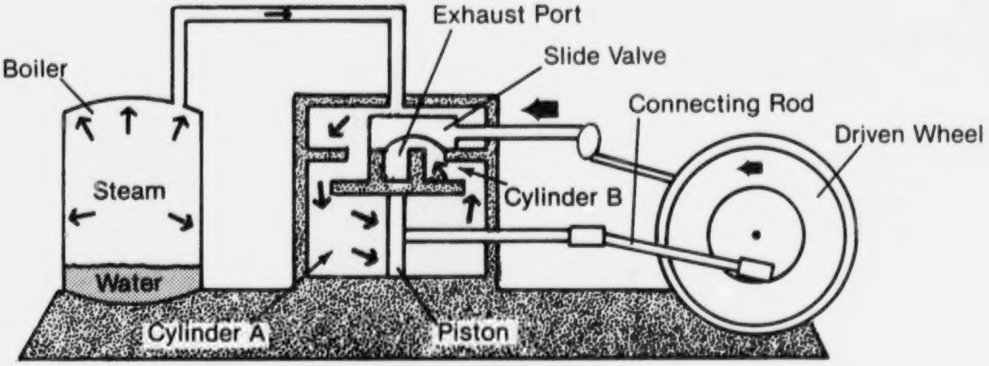
Internal Combustion Engine


Steam
Water
Piston
Cylinder
Combustion of Fuel
Crankshaft

External Combustion Engine

TM 1

External Combustion Engines


Exhaust Port
Slide Valve
Boiler
Connecting Rod
Driven Wheel
Steam
Cylinder B
Water
Cylinder A
Piston

Steam Engine

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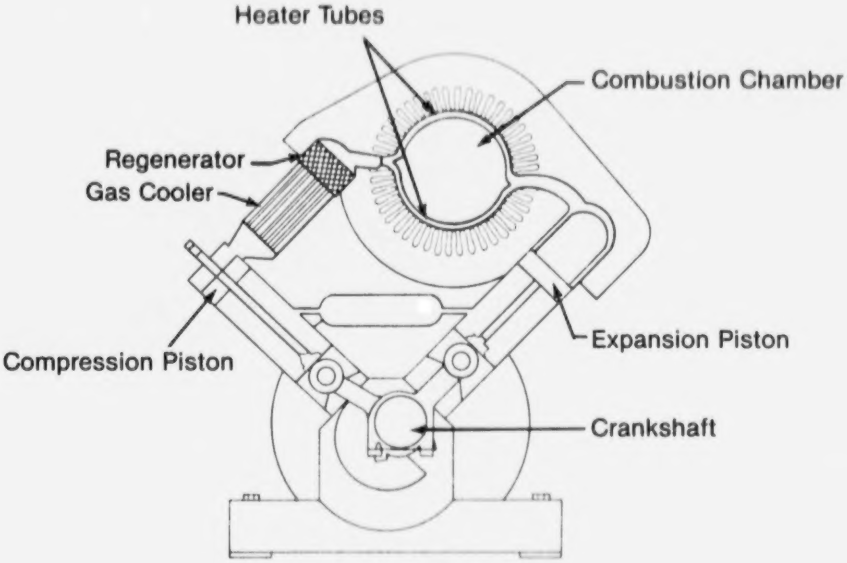
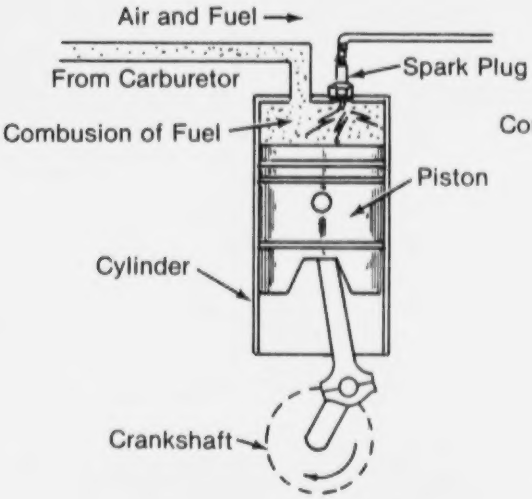
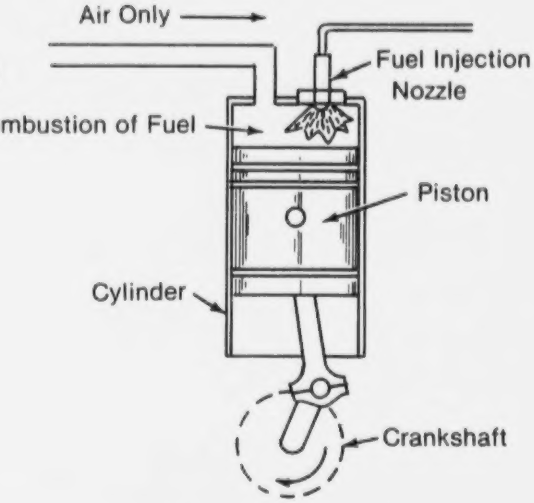

Heater Tubes
Combustion Chamber
Regenerator
Gas Cooler
Compression Piston
Expansion Piston
Crankshaft

Stirling Engine

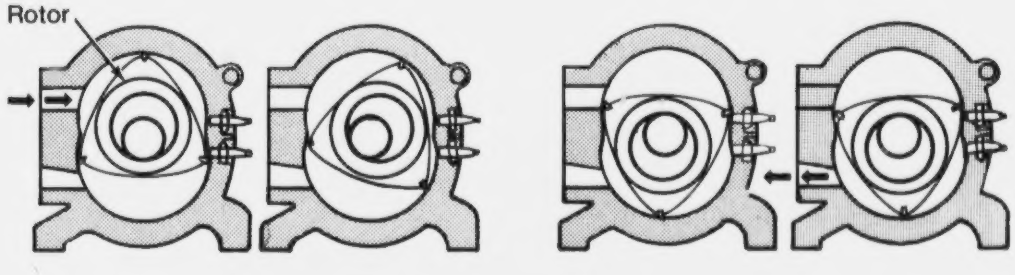
Internal Combustion Engines


Air and Fuel
From Carburetor
Spark Plug
Combusion of Fuel
Piston
Cylinder
Crankshaft

Gasoline Engine


Air Only
Fuel Injection Nozzle
Combustion of Fuel
Piston
Cylinder
Crankshaft

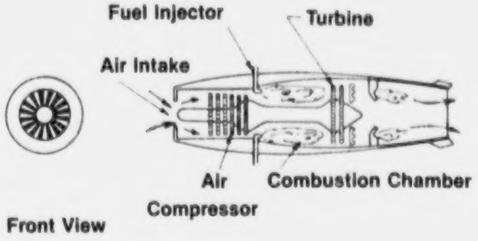
Diesel Engine



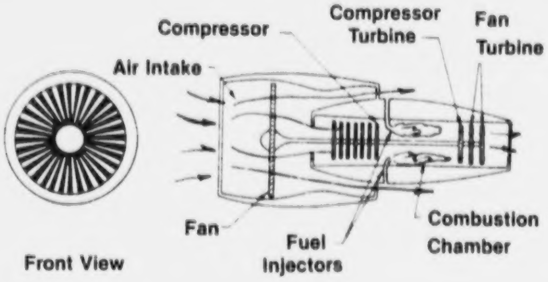
Intake Compression Power Exhaust

Rotary Engine

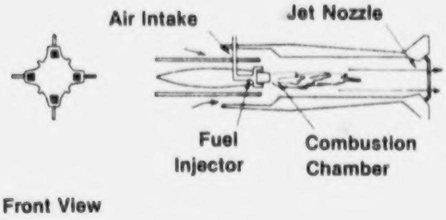
Internal Combustion Engines
(Continued)


Fuel Injector
Turbine
Air Intake
Air Compressor
Combustion Chamber
Front View

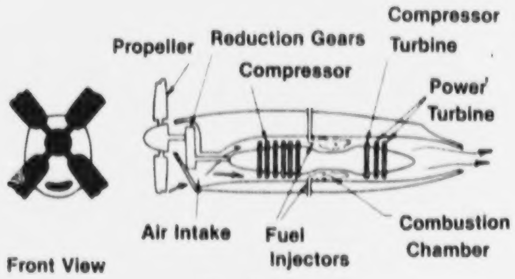
Turbojet


Compressor
Compressor Turbine
Fan Turbine
Air Intake
Fan
Fuel Injectors
Combustion Chamber
Front View

Turbofan

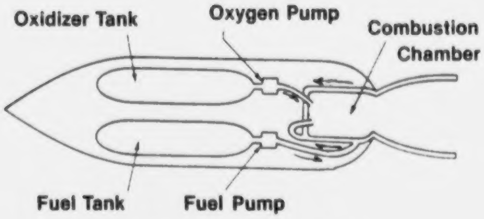

Air Intake
Jet Nozzle
Fuel Injector
Combustion Chamber
Front View

Ramjet

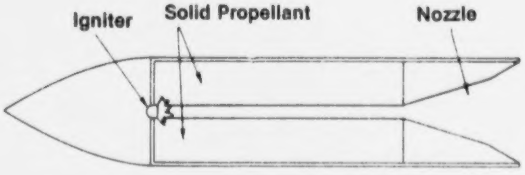

Propeller
Reduction Gears
Compressor
Compressor Turbine
Power Turbine
Air Intake
Fuel Injectors
Combustion Chamber
Front View

Turboprop

Jet Engines


Oxidizer Tank
Oxygen Pump
Combustion Chamber
Fuel Tank
Fuel Pump

Liquid-Propellant


Igniter
Solid Propellant
Nozzle

Solid-Propellant

Rocket Engines

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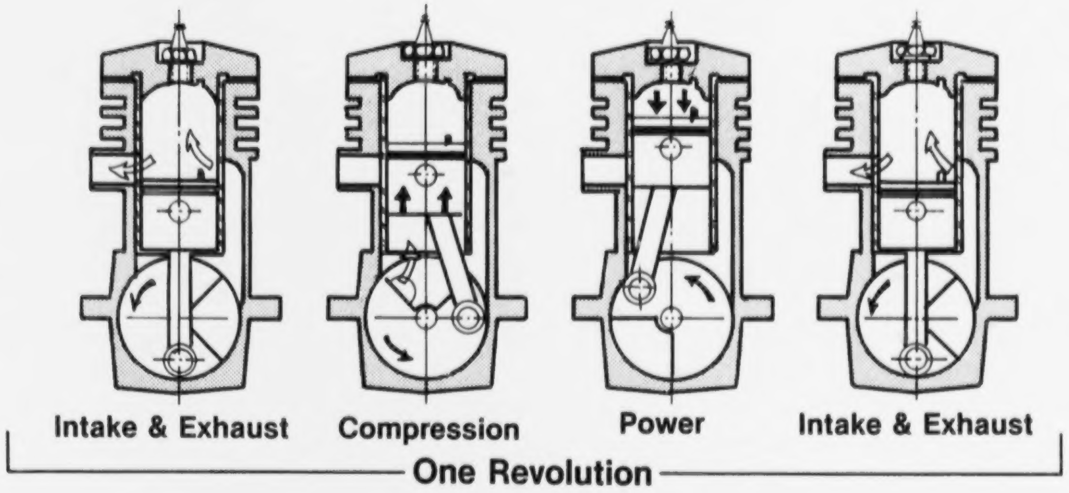
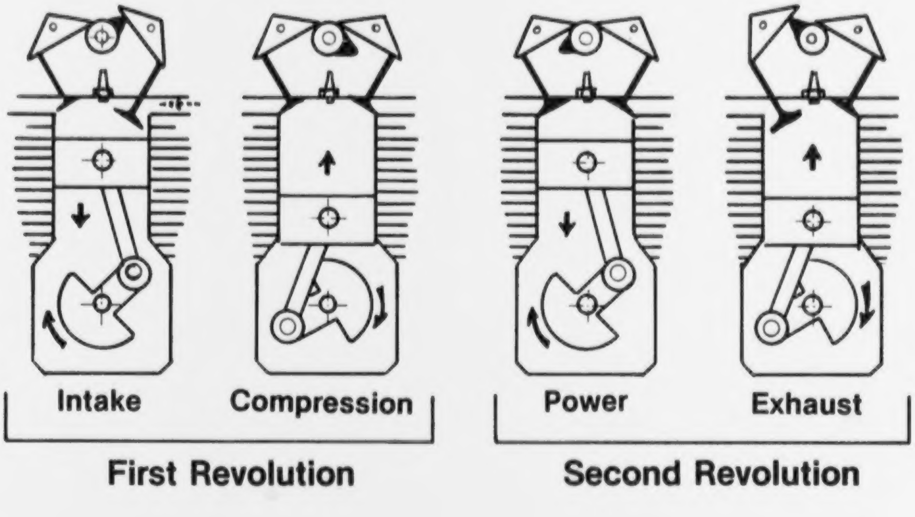
Operation of Gasoline Engines

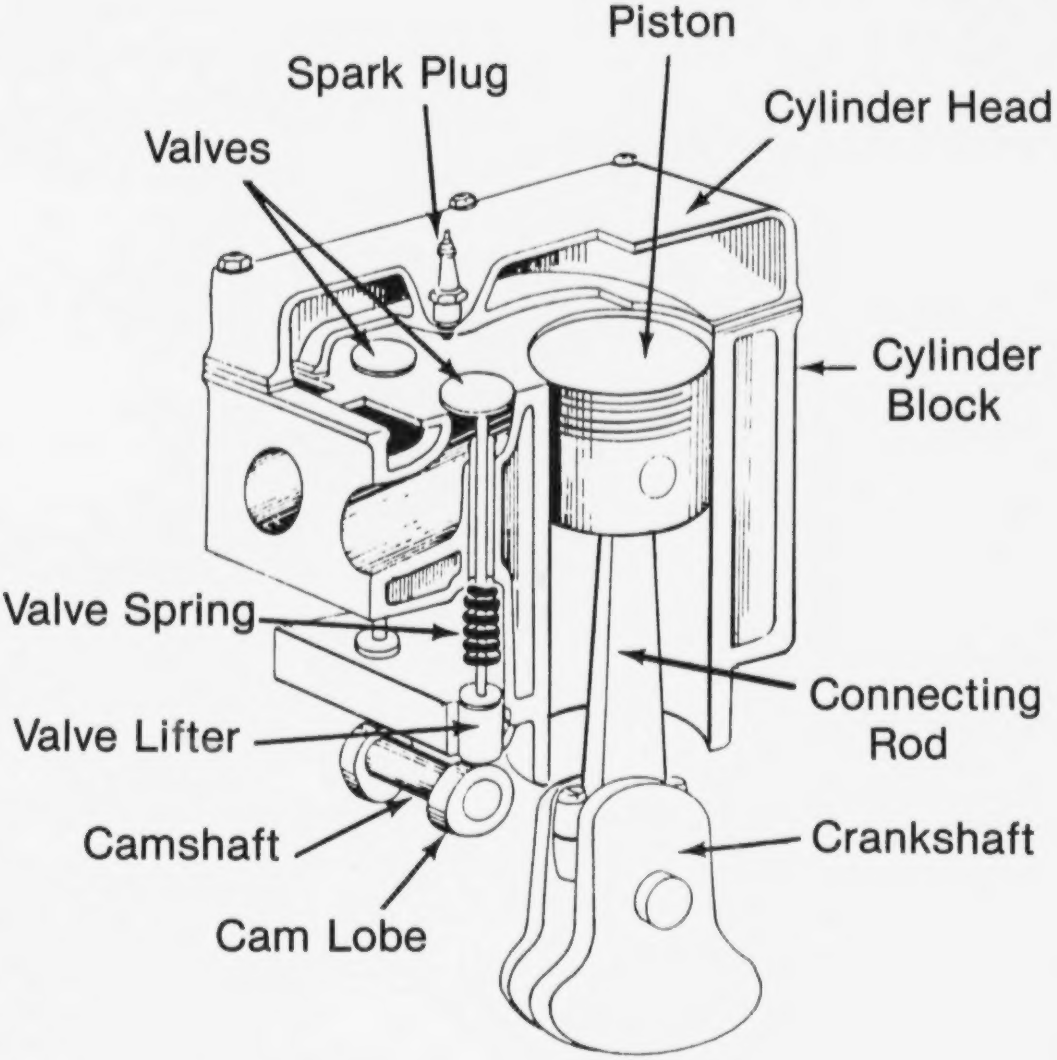

Intake & Exhaust
Compression
Power
Intake & Exhaust
One Revolution

Two-Stroke Cycle Engine

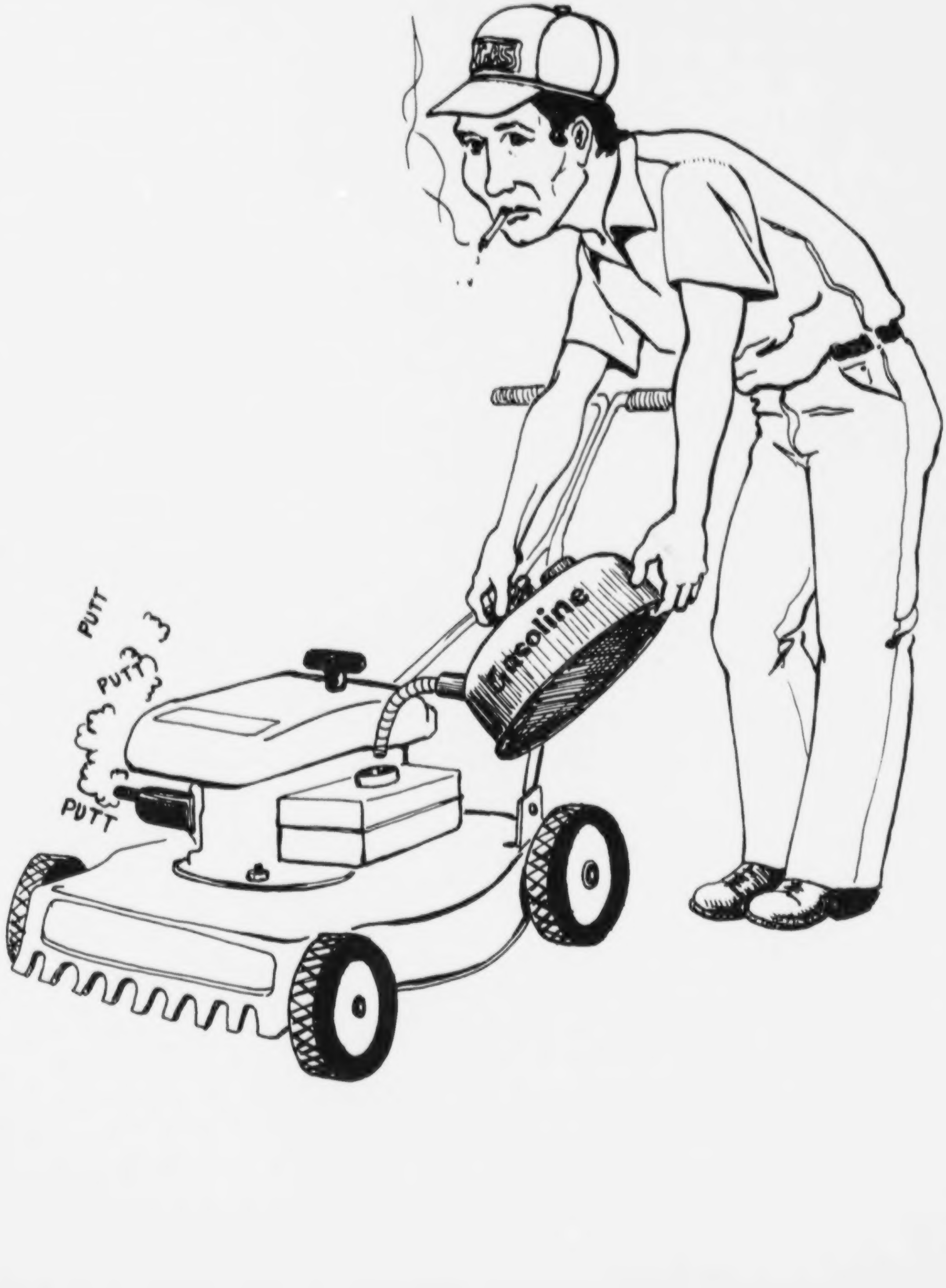

Intake
Compression
Power
Exhaust
First Revolution
Second Revolution

Four-Stroke Cycle Engine

Basic Internal Combustion Engine Parts


Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Camshaft
Crankshaft
Cam Lobe

Use Care With Gasoline


PUTT
PUTT
PUTT
Gasoline

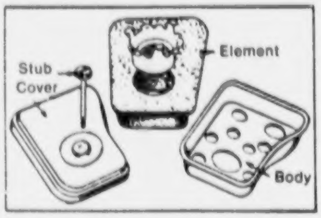
TM 7

POWER PRODUCTION AND CONVERSION
UNIT III

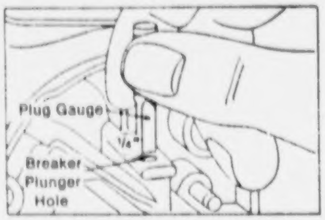
ASSIGNMENT SHEET #1 — CHECK ENGINE COMPONENTS FOR WEAR

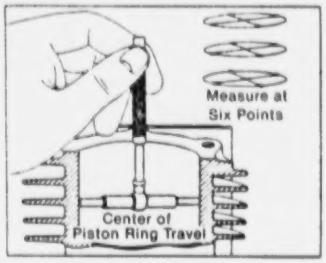
Directions: Complete this assignment after the engine is disassembled in Job Sheet #1. When examining engine, describe condition of parts and give dimensions as indicated. If parts are broken or cracked, mark location of break on drawing. Report condition of engine with check (✓) mark where possible.

1. Air Cleaner
   Element
   ______Dry____________________
   ______Clean__________________
   ______Dirty__________________
   Mounting Gasket:
   Missing______ Worn______
   Air Cleaner Stud:
   Bent______ Broken______

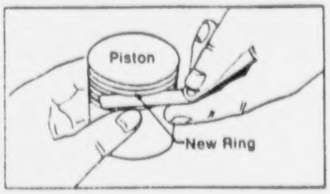

Stub
Cover
Element
Body

2. Cylinder
   Fins: Clean______ Clogged______
   Bore: Scored______ Worn______
   *Bore Size:
   Top ______________________
   Center ____________________
   Bottom ____________________
   Contact Plunger Hole:
   OK______ Worn______


Plug Gauge
1/4"
Breaker
Plunger
Hole

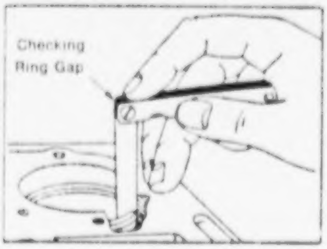

Measure at
Six Points
Center of
Piston Ring Travel

3. Piston
   Scored______ Scratched______
   Ring Groove: Worn ______________
   Galled ____________________
   Broken ____________________

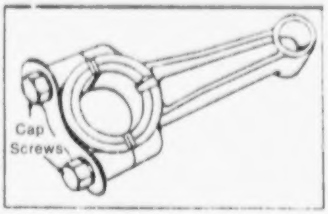

Piston
New Ring

ASSIGNMENT SHEET #1

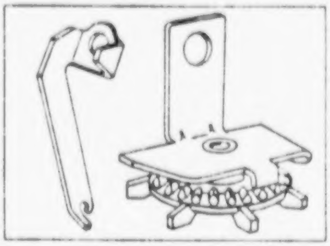
4. Piston rings
Top Ring Gap ____________
Ctr. Ring Gap ____________
Oil Ring Gap ____________
____
____
____
____


Checking
Ring Gap

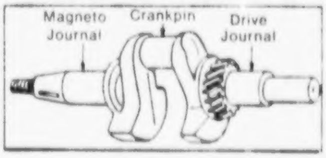
5. Connecting rod
Discolored ____________
Broken ____________
Bearing Scored ____________
Cap Screws Loose ____________
Dipper:
Bent ____________
Broken ____________



6. Oil Slinger
Damage ____________
____
____



7. Crankshaft
Magneto Journal:
Worn______ Scored______
*Size ____________
Crankpin:
Worn______ Scored______
*Size ____________
Drive Journal:
Worn______ Scored______
*Size ____________
P.T.O.:
Bent______ Broken______


Magneto
Journal
Crankpin
Drive
Journal

ASSIGNMENT SHEET #1

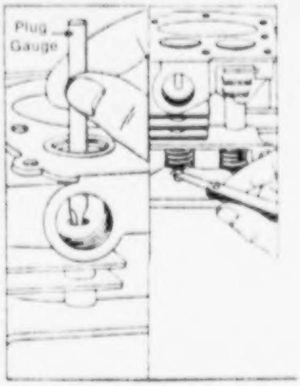
8. Main Bearings

Drive Side Mag. Side

______________Worn______________

______________Scored______________

______________*Size______________



Courtesy of Briggs and Stratton

9. Valves

Face Burned EX.______ INT.______

Guide Worn? EX.______ INT.______

Clearance

INT. ____________________

EX. ____________________

POWER PRODUCTION AND CONVERSION
UNIT III

JOB SHEET #1 — DISASSEMBLE AND REASSEMBLE A FOUR CYCLE, ONE CYLINDER ENGINE

A. Tools and materials

1. Gasoline container, for drained gasoline
2. Oil container, for drained oil
3. Metal pan to hold engine
4. Four cycle, one cylinder engine (Briggs and Stratton shown)

   (NOTE: Slight variations should be made in the procedure for other brands of engines.)
5. Parts cleaner pan
6. Penetrating oil
7. Pipe wrench
8. Flywheel holder
9. Clutch wrench
10. Parts cleaning brush
11. Feeler gauge
12. Wire gauge
13. Valve spring compressor tool
14. Flywheel puller
15. Ring compressor tool
16. Telescoping gauge
17. Torque wrench
18. Direct reading
19. Micrometer
20. Combination wrench set
21. Ring expander tool

JOB SHEET #1

22. Piston ring groove cleaner
23. Plug gauge
24. Reject gauge
25. Ring grooving tool

B. Procedure

(NOTE: **Before** starting this job sheet — **read** safety criteria in manufacturer's manual.)

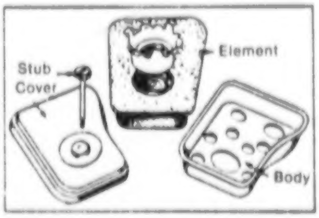
1. Place engine in metal pan on workbench.
2. Disconnect spark plug wire from spark plug.
3. Drain gasoline tank into designated container.
4. Drain oil out of crankcase into designated container.
5. Obtain copy of manufacturer's manual for your engine from your lab library.
6. Follow procedure recommended by the manufacturer in disassembling your engine.
7. Record nameplate data:
    a. Manufacturer ______________________
    b. Serial No. ______________________
    c. Model No. ______________________
    d. Horsepower ______________________
    e. No. of Cylinders ______________________
8. Remove air cleaner and clean parts, except filter, in the parts cleaner pan.
9. Fill in the information regarding condition of air cleaner.

AIR CLEANER ELEMENT

________ Dry ______________
________ Clean ______________
________ Dirty ______________

MOUNTING GASKET:
Missing ______ Worn ______

AIR CLEANER STUD:
Bent ______ Broken ______



JOB SHEET #1

10. Wipe air cleaner parts dry following removal from cleaner pan.

11. Remove muffler **only** to replace.

    a. Use penetrating oil, if badly rusted, on the threads.

    b. Allow it to soak until next day.

    c. Remove with a pipe wrench.

    (NOTE: Some engines have a locking nut on the muffler pipe. Be sure to loosen locking nut first.)

12. Remove fuel lines, filter (if provided), and connections between the fuel tank and carburetor.

13. Remove carburetor linkage after making a sketch for reassembling.

14. Remove breather pipe.

    (NOTE: On some models this is located between the valve cover and carburetor.)

15. Remove carburetor assembly.

16. DO NOT disassemble at this time.

    (NOTE: On suction fuel, be very careful not to bend brass tubes on the bottom of the carburetor.)

17. Remove fuel tank.

    (NOTE: Some models may have fuel tank and blower housing spot welded together. If so, remove as a unit — the tank and the blower housing.)

18. Remove blower housing.

    (NOTE: This may be called flywheel guard.)

19. Spin flywheel with rope or by hand to check compression.

20. Record results of the compression check:

    a. Good ____________________

    b. Fair ____________________

    c. Poor ____________________

    (NOTE: It should rebound sharply when turned quickly against compression to be considered good.)

JOB SHEET #1

21. Use feeler gauge and check air gap armature to fly wheel, both sides — left and right.

22. Record gap clearance for:
    a. Left side ____________
    b. Right side ____________

23. Remove spark plug.

24. Check gap with wire gauge.

25. Record spark plug gap.____________

26. Clean spark plug.

27. Remove governor blade (air vane) CAREFULLY to prevent damage to blade.

28. Remove rope starter pulley using special tool to hold the flywheel.

29. Inspect the threaded end of the shaft to determine whether it is left or right threaded before loosening nut.

    (NOTE: Briggs & Stratton engines are usually left thread. If a recoil starter, remove clutch by turning clockwise.)

30. Remove valve cover plate CAREFULLY so as not to damage gasket.

31. Remove cylinder head being careful not to mar mating surface.

32. Check tappet clearance with feeler gauge and record.
    a. Valve clearance-intake — ______________________________
    b. Valve clearance-exhaust — ______________________________
    c. Manufacturer's recommended clearance — ____________________

33. Remove valve springs, using valve spring compression tool.

    (NOTE: Do not lose the small washers in removal.)

34. Measure and record the following on both valves.

		Intake	Exhaust
a.	Face		
b.	Margin		
c.	Stem		
d.	Guide		

JOB SHEET #1

35. Remove the fly wheel, using puller best suited for your model.

    (NOTE: Be sure to pick up the key.)

36. Remove breaker point cover.

37. Measure and record breaker point gap with feeler gauge.

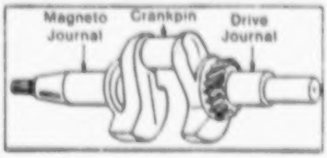
    Breaker point gap ____________

38. Remove breaker arm assembly and condenser taking care not to damage or lose the plunger or cam.

39. Remove ignition wire.

40. Check crankshaft and play.

41. Record wear on magneto journal, crankpin, and drive journal.



Crankshaft
Magneto Journal:
Worn______ Scored______
*Size ______________________
Crankpin:
Worn______ Scored______
*Size ______________________

Drive Journal:
Worn______ Scored______
*Size ______________________
P.T.O.:
Bent______ Broken______

42. Inspect crankshaft extension for burrs.

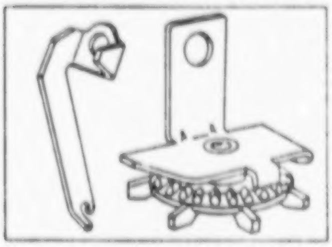
43. Remove all burrs with emery cloth or by filing.

44. Remove crankcase cover (starter plate).

45. Turn upside down, with vertical shaft, so camshaft will not fall out before timing can be noted.

46. Remove oil pump, dipper or slinger.

    Record any damage.



Oil Slinger
Describe damage______________
____
____

JOB SHEET #1

47. Inspect timing gears for timing marks.

48. Remove camshaft gear and tappets.

49. Remove connecting rod and piston assembly.

50. Check connecting rod and cap for mating marks before removing and record the following:

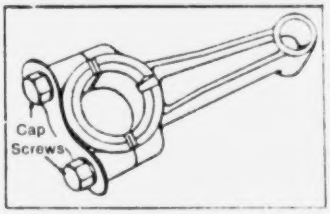
    a. Carb. side ______________

    b. Intake side ______________

    c. Exhaust side ______________

    d. Flywheel side ______________

    e.



Connecting Rod
Discolored ______________________
Broken ______________________
Bearing Scored ______________________
Cap Screws Loose ______________________
Dipper:
Bent ______________________
Broken ______________________

51. Remove crankshaft assembly.

52. Measure the diameter of crankshaft journals and main bearings with micrometer.

    a. Main bearings

DRIVE SIDE		MAG. SIDE
______________________	Worn	______________________
______________________	Scored	______________________
______________________	*Size	______________________

53. Disassemble connecting rod and piston.

54. Measure the diameter of the following:

    a. Crankpin bearing (on crankshaft) ______________________

    b. Crankpin journal ______________________

    c. Piston pin bearing or piston ______________________

    d. Piston pin journal ______________________

JOB SHEET #1

55. Measure and record clearance of rings on piston:

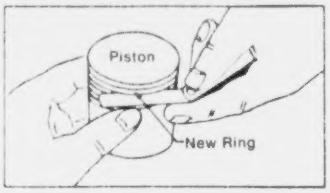
	Compression rings	Clearance
a.	Top No. 1	____________
b.	Top No. 2	____________
c.	Oil ring	____________

56. Remove rings from piston with ring expander tool.

57. Clean the ring grooves with a ring grooving tool.

58. Record the following information:

Piston
Scored______Scratched______
Ring Groove: Worn _______
Galled ________________
Broken ________________

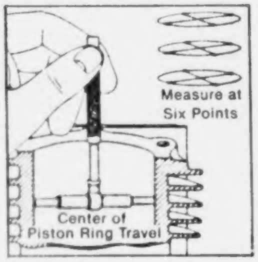

Piston
New Ring

59. Measure the diameter of the cylinder at six points.

    a. Two, at top ____________ ____________

    b. Two, at middle ____________ ____________

    c. Two, at bottom ____________ ____________


Measure at Six Points
Center of Piston Ring Travel

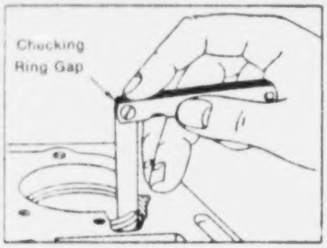
60. Measure diameter of the piston at four points.

    a. Two, at top ____________ ____________

    b. Two, at bottom ____________ ____________

61. Measure and record ring gap of each ring by inserting the ring in the cylinder and measuring the gap with the feeler gauge.

(NOTE: Rings must be perfectly horizontal in the cylinder to get accurate measurement.)


Checking Ring Gap

JOB SHEET #1

62. Record compression ring gap.
    a. Top No. 1 ______________
    b. Top No. 2 ______________
    c. Oil ring ______________
63. Clean all parts and inspect for wear.
64. Complete Assignment Sheet #1 at this point.
65. Replace parts which are worn beyond manufacturer's recommended limits.
66. Make new gaskets, if required.
67. Dress down all mating surfaces which are scratched or marred before reassembling.
68. REASSEMBLE.

POWER PRODUCTION AND CONVERSION
UNIT III

JOB SHEET #2 — CONSTRUCT A SOLAR BATTERY

A. Tools and materials

1. Tools

    a. Voltmeter (0-1 and 0-10 volt range)

    b. Ammeter (0-1 and 0-10 ampere range)

    c. ¾″ drill

    d. Square

2. Materials

    a. 1 - ¾″ × 8″ × 8″ plywood or board

    b. 1 - ¾″ dowel rod, 9″ long

    c. Glue

    d. 1 - #49 lamp socket and bulb

    e. 6 - Photovoltaic cells, 400-500 MA (milliampere capacity)

    f. 14 - quick disconnect connectors

    g. 10 - bell wires*, 6″ long (*#18-#22 gauge multiple-strand flexible insulated wire)

    h. 6 - bell wires*, 12″ long

    i. 1 - ¾″ × 8″ × 12″ plywood base

    j. 1 - ¾″ × 3″ × 3″ plywood base

    k. Fasteners

B. Procedure

1. Drill a ¾″ hole in the center of the 8″ × 8″ plywood or board.

2. Brush glue in all parts of the hole.

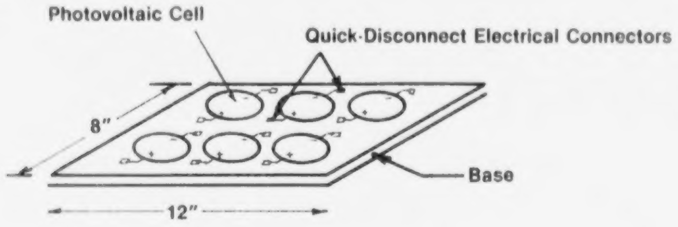
JOB SHEET #2

3. Insert dowel rod making sure it does not extend from the bottom.

4. Using a square, check the angle of the dowel rod and board to ensure a 90° angle is formed in all directions — BEFORE THE GLUE SETS. This is your "sun target."

5. Arrange the six photovoltaic cells so that they are evenly spaced on the plywood base.

FIGURE 1

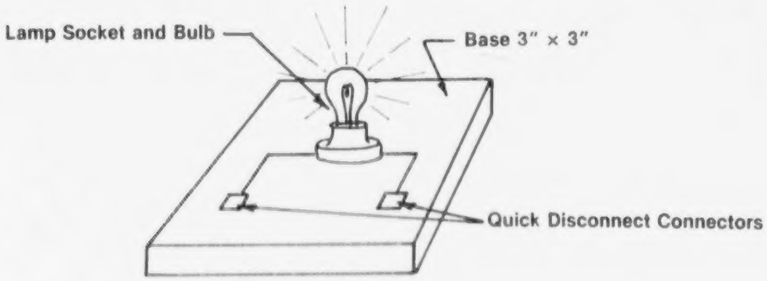

Photovoltaic Cell
Quick-Disconnect Electrical Connectors
8"
Base
12"

6. Glue the cells to the base, and number them.

7. Connect each cell electrical lead to a quick disconnect and fasten them to the mounting board as shown in Figure 1.

8. Mount the lamp socket and bulb in the center of the base using an adhesive to secure it to the base.

FIGURE 2


Lamp Socket and Bulb
Base 3" × 3"
Quick Disconnect Connectors

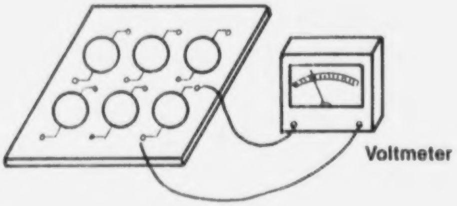
9. Connect the socket electrical leads to the quick disconnects and fasten them to the board. See Figure 2.

JOB SHEET #2

10. Test each cell one at a time using voltmeter.

    (NOTE: When placed in the sun each cell operates as a small source of electricity. The voltage of each cell will be approximately 0.45V, and the amperage up to the rated capacity of the cell. Cell output will also depend upon the available light.)

    FIGURE 3



11. Place cells in sunlight.

    (NOTE: A lamp or other light source may be used if sunlight is not available.)

12. Use sun target to position cells for maximum output.

    (NOTE: Point the dowel toward the sun so that NO shadow is cast by the dowel. The base is now at a right angle to the sun and is receiving maximum sunlight.)

13. Place base of target on cells and adjust until dowel casts NO shadow to ensure maximum sunlight. Remove sun target.

    (NOTE: Since photovoltaic cells convert radiant energy as it is received, you can see the output vary as you move the mounting board and cells.

14. Read and record the voltage of each cell:

Cell 1 ______________ Cell 4 ______________

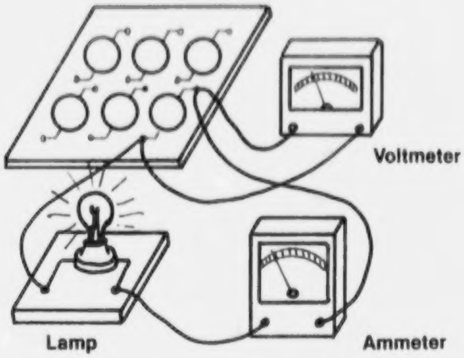
Cell 2 ______________ Cell 5 ______________

Cell 3 ______________ Cell 6 ______________

JOB SHEET #2

15. Connect the lamp, ammeter, and voltmeter to a single cell.

FIGURE 4



(NOTE: The ammeter is wired in series — all electricity passing through the lamp also passes through the ammeter. The voltmeter is wired in parallel — it measures electrical pressure and the circuit electricity does **not** pass through it.)

16. Record the voltage and amperage.

Voltage ______________

Amperage ______________

17. Describe the brightness of the lamp.

____

____

____

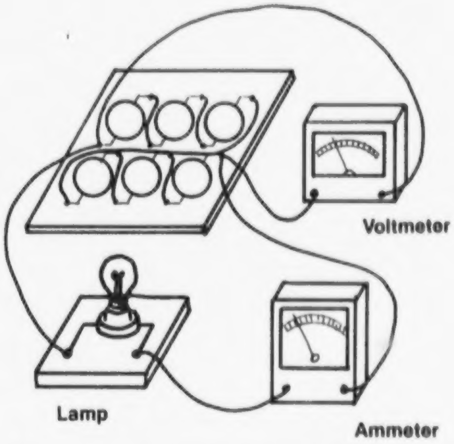
____

JOB SHEET #2

18. Add cells in series as shown in Figure 5.

(NOTE: Note that cells wired in series have all the electricity passing through each cell.)

FIGURE 5



(NOTE: This will provide a higher voltage at a constant amperage to the lamp.)

19. Record voltage and amperage with 2, 4, 6 cells in series.

Cells in Series	2	4	6
Voltage			
Amperage			

20. Is voltage increased, decreased, or does it stay the same as cells are added? _

21. Is amperage increased, decreased, or does it stay the same as cells are added? _

22. Describe what happens to the brightness of the lamp.

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POWER PRODUCTION AND CONVERSION
UNIT III

PRACTICAL TEST
JOB SHEET #1 — DISASSEMBLE AND REASSEMBLE A FOUR CYCLE, ONE CYLINDER ENGINE

STUDENT'S NAME ______________________ DATE __________

EVALUATOR'S NAME ______________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	____	____
2. Drained oil and gasoline.	____	____
3. Removed carburetor assembly.	____	____
4. Removed flywheel guard, starter pulley, flywheel, and ignition system.	____	____
5. Removed crankcase cover, gears, tappets, and crankshaft assembly.	____	____
6. Removed piston and rings.	____	____
7. Cleaned all parts.	____	____
8. Completed Assignment Sheet #1.	____	____
9. Replaced piston and rings.	____	____
10. Replaced crankshaft assembly, crankcase cover, gears, and tappets.	____	____
11. Replaced ignition system, flywheel guard, starter pulley, and flywheel.	____	____
12. Replaced carburetor assembly, oil, and gasoline.	____	____
13. Checked in/put away tools and materials.	____	____
14. Cleaned the work area.	____	____
15. Used proper tools correctly.	____	____
16. Performed steps in a timely manner (___hrs. ___min. ___sec.)	____	____
17. Practiced safety rules throughout procedure.	____	____
18. Provided satisfactory responses to questions asked.	____	____

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Disassembled Engine	Major Components Disassembled Properly	Muffler	Valves Springs	Crankshaft/ Piston
	4	3	2	1
Cleaned parts	No Varnish/ Carbon Grease	Varnish and Carbon	Dirt and grease in Crevices	Dirty/ Greasy
	4	3	2	1
Measured Required Parts	Accurate/ Complete	Piston Measurements Incorrect	Cylinder Incorrect	Crankshaft Incorrect
	4	3	2	1
Reassembled Motor	Complete/ Running Condition	Carburetor/ Linkage	Ignition/ Coil	Motor Will Not Rotate

EVALUATOR'S COMMENTS: ______________________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

POWER PRODUCTION AND CONVERSION
UNIT III

PRACTICAL TEST
JOB SHEET #2 — CONSTRUCT A SOLAR BATTERY

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. _____

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Made sun target.	______	______
3. Arranged, mounted, and numbered photovoltaic cells on base.	______	______
4. Connected each cell's lead to quick disconnect and fastened to mounting board.	______	______
5. Mounted #49 lamp to base and connected leads to quick disconnects.	______	______
6. Tested cells with voltmeter.	______	______
7. Used sun target to position cells in sunlight for maximum output.	______	______
8. Read and recorded voltage of each cell.	______	______
9. Connected lamp, ammeter, and voltmeter to single cell; recorded voltage and amperage.	______	______
10. Described brightness of lamp.	______	______
11. Added cells in series and recorded voltage and amperage with 2, 4, 6 cells.	______	______
12. Noted increase/decrease in amperage, voltage, and brightness of lamp.	______	______
13. Checked in/put away tools and materials.	______	______
14. Cleaned the work area.	______	______
15. Used proper tools correctly.	______	______
16. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
17. Practiced safety rules throughout procedure.	______	______
18. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Sun target	Dowel 90° in all directions	Dowel flush with base on bottom	Dowel extends below base	Dowel **not** 90° with base
	4	3	2	1
Photovoltaic cells and lamp mounted on bases	Mounted correctly	Connections attached correctly	Connections improperly installed	Solar cells do not function
	4	3	2	1
Tested solar battery	Cells functioning to rated capacity	Weak or improper connections	Wiring not in series	**No** voltage or amperage registered

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

POWER PRODUCTION AND CONVERSION
UNIT III

NAME ______________________________ SCORE ______________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. A substance that does not allow the transmitting of electricity

_____b. Process of burning

_____c. A forward push or force

_____d. Current that flows through a conductor in only one direction

_____e. A connected group of cells storing an electrical charge and capable of furnishing a current

_____f. Back and forth movement

_____g. Reducing the volume of air or air-fuel mixture by pressure

_____h. The movement of electrons through a conductor

_____i. The movement of a piston from one end of a cylinder to the other

_____j. The complete path of an electric current

1. Alternating current (AC)
2. Battery
3. Cell
4. Circuit
5. Combustion
6. Compression
7. Conductor
8. Current
9. Direct current (DC)
10. Insulator
11. Reciprocating motion
12. Rotary motion
13. Stroke
14. Thrust

2. Distinguish between direct and indirect conversion by placing an "X" next to the characteristic of direct conversion.

_____a. When several conversions take place before the energy is in the right form to do work

_____b. When energy is used after only one conversion

TEST

3. Select true statements concerning common direct conversion systems by placing an "X" in front of the true statements.

   a. Fuel cells

      ______1) Convert chemical energy (fuel) indirectly into electric energy.

      ______2) Will provide a continuous flow of electric current as long as the fuel supply is continuous.

      ______3) Differs from an ordinary battery in that the electrodes are NOT consumed as they are in a battery.

      ______4) The most successful fuel cell is the Hydrox cell which is fueled by liquid nitrogen which mixes with liquid oxygen.

   b. Solar cells

      ______1) Are crystals (selenium or silicon) that convert solar energy directly into electricity

      ______2) Are relatively inexpensive and are very efficient

      ______3) Are most useful where weight is a factor and voltage demands are low

4. Match common methods of converting energy on the right with the correct definitions.

   ______a. Convert any form of energy into mechanical energy

   ______b. An electrical- or fluid-operated device that converts energy to mechanical energy

   ______c. Convert mechanical (rotary) energy into electrical energy

   ______d. Rotating devices driven by wind, steam, or water that are used to drive electric generators

   1. Generator
   2. Engines
   3. Turbines
   4. Motors

5. Select true statements concerning the conversion of electrical power by placing an "X" next to the true statements.

   ______a. Generators are used to convert mechanical energy into electrical energy.

   ______b. There are two types of generators, AC and BC.

   ______c. Generators vary in size. Small generators are used to provide electric power for cities.

   ______d. Large generators are usually powered by steam turbines or hydroelectric power.

TEST

6. Distinguish between the classifications of engines by placing an "E" in front of the characteristics of external combustion engines and an "I" in front of internal combustion engine characteristics.

_____a. Produces power by the continuous combustion of a fuel source burned outside of the engine.

_____b. Produces power by the intermittent (not continuous) combustion of a fuel/air mixture in a combustion chamber in the engine.

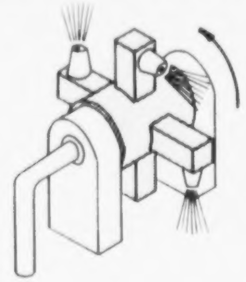
_____c. Expanding hot gases in chamber produce work by pushing a piston, turning a turbine, or producing reaction propulsion.

_____d. Burning fuel converts a working fluid (usually water) into a high pressure vapor which is then delivered to the engine.

7. Complete the following statements concerning the types of external combustion engines by circling the correct words.

a. Steam engines use (**fuel combustion, steam pressure**) to drive pistons and produce motion.

b. The type of steam turbine shown below is the (**impulse type, reaction type**).



c. The Stirling engine commonly uses (**gasoline, steam, hydrogen**) for pressure to move the piston(s).

d. The Stirling engine is (**more, less**) fuel-efficient and powerful than an internal combustion engine.

TEST

8. Match types of internal combustion engines on the right with the correct descriptions.

_____a. The rearward expulsion of hot gases creates an opposite reaction which propels the craft forward.

_____b. Cycle has four actions — Intake, compression, combustion, and exhaust.

_____c. Produces three power strokes for every rotor revolution.

_____d. The air and the fuel is mixed inside the cylinder and there is no electrical spark to ignite the fuel.

1. Gasoline engine
2. Diesel engine
3. Rotary engine
4. Jet and rocket engines

9. Distinguish between the operations of a two-stroke and four-stroke cycle engine by placing a "2" in front of two-stroke engine operations and "4" in front of four-stroke engine operations.

_____a. Power stroke

1) As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture.
2) Burning gases expand very rapidly and force the piston down the cylinder.

_____b. Power stroke

1) Compressed fuel-air mixture is ignited. Pressure from expanding gases forces the piston downward.
2) Exhaust gases are forced out the exhaust ports of the cylinder.

_____c. Compression stroke

1) Air-fuel mixture is compressed tightly as the piston moves up the cylinder.
2) Compression of the fuel creates heat which prepares the fuel for instant ignition.

_____d. Exhaust stroke

1) When piston is at the bottom position (BDC), fuel-air mixture enters cylinder through ports in cylinder wall.
2) Piston moves up cylinder and compresses fuel-air mixture.

_____e. Compression stroke

1) When piston is at the bottom position (BDC), fuel-air mixture enters cylinder through ports in cylinder wall.

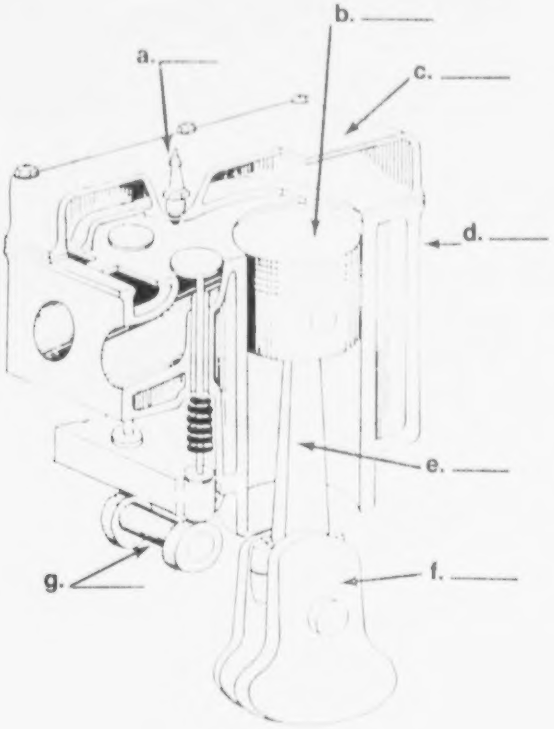
2) Piston moves up cylinder and compresses fuel-air mixture.

TEST

_____f. Intake stroke

1) Cycle starts with piston at uppermost position in cylinder (TDC) with intake valve open and exhaust valve closed.
2) As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor.
3) When the piston reaches the bottom of the cylinder (BDC), the intake valve closes.

10. Identify the parts of an internal combustion engine. Choose your answers from the list at the right.



1. Connecting rod
2. Valve spring
3. Cam lobe
4. Cam shaft
5. Piston
6. Valves
7. Cylinder head
8. Spark plug
9. Cylinder block
10. Valve lifter
11. Crankshaft

TEST

11. Match the systems of an engine on the left with the correct functions and parts.

______a. 1) Function — Mixes air and fuel properly and delivers the mixture to the combustion chamber
2) Parts involved — Air cleaner, fuel supply tank, valve, oil filter, carburetor, governor

______b. 1) Function — Removes excess heat from the engine
2) Parts involved — Cylinder block and head when air cooled or a water jacket and pump when water cooled

______c. 1) Function — Sets the engine in motion
2) Parts involved — Manual or electric starters

______d. 1) Function — Oils engine parts to reduce friction and wear
2) Parts involved — Oil pump and valves

______e. 1) Function — Produces the spark that ignites the fuel
2) Parts involved (depending on type of system) — Armature, magnets, breaker points, condenser, spark plug, battery

______f. 1) Function — Develops up-and-down motion and converts it into useful rotary motion
2) Parts involved — Cylinder block and head, piston, connecting rod, crankshaft, camshaft, valves

1. Mechanical system
2. Lubrication system
3. Cooling system
4. Fuel system
5. Ignition system
6. Starting system

12. Complete statements concerning safety rules by placing the number of the appropriate word in the blank.

______a. Wear ______________ or goggles at all times. Remember that your eyes can't be replaced. Protect them.

______b. Wear approved ______________ protectors while working with running engines. Some are very noisy and can permanently damage your hearing.

______c. Store ______________ in approved safety cans in the storage areas designated by your instructor.

1. Immediately
2. Engines
3. Fuel
4. Ear
5. Safety glasses
6. Battery

TEST

_____d. Do not inhale fumes from _____________ or solvent containers. The fumes can seriously damage your lungs.

_____e. Have adequate ventilation when running _____________, or where fumes may be a hazard.

_____f. Wash your hands thoroughly if _____________ splashes on them. It is very harsh and usually contains additives that are poisonous when absorbed through the skin.

_____g. Never use _____________ to clean parts; only use cleaning solvents.

_____h. Wipe up any fuel spills _____________.

_____i. Be careful when handling an engine _____________. It contains acid which can ruin your clothes, burn your skin, and blind you if it gets in your eyes.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

13. Check engine components for wear. (Assignment Sheet #1)

14. Demonstrate the ability to:

    a. Disassemble and reassemble a four cycle, one cylinder engine. (Job Sheet #1)

    b. Construct a solar battery. (Job Sheet #2)

POWER PRODUCTION AND CONVERSION
UNIT III

ANSWERS TO TEST

1. a. 10
   b. 5
   c. 14
   d. 9
   e. 2
   f. 11
   g. 6
   h. 8
   i. 13
   j. 4

2. b

3. a. 2, 3
   b. 1, 3

4. a. 2
   b. 4
   c. 1
   d. 3

5. a, d

6. a. E
   b. I
   c. I
   d. E

7. a. Steam pressure
   b. Reaction type
   c. Hydrogen
   d. More

8. a. 4
   b. 1
   c. 3
   d. 2

9. a. 4
   b. 2
   c. 4
   d. 4
   e. 2
   f. 4

10. a. 8
    b. 5
    c. 7
    d. 9
    e. 1
    f. 11
    g. 4

ANSWERS TO TEST

11. a. 4
    b. 3
    c. 6
    d. 2
    e. 5
    f. 1

12. a. 5
    b. 4
    c. 3
    d. 3
    e. 2
    f. 3
    g. 3
    h. 1
    i. 6

13. Evaluated to the satisfaction of the instructor

14. Performance skills evaluated to the satisfaction of the instructor

POWER TRANSMISSION AND STORAGE
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between devices and operations of mechanical power, electrical power, and fluid power systems. The student should also be able to determine gear rotation, design and build a robotic arm, and build a "big track" robot. Competencies will be demonstrated by completing the assignment sheets, job sheets, and unit tests with a minimum of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to power transmission and storage with the correct definitions.
2. Distinguish between the types of power systems.
3. Identify devices for control and transmission of mechanical power.
4. Complete statements concerning the transmission of electrical power.
5. Match devices for control of electrical power with the correct descriptions.
6. Select true statements concerning the principles of hydraulics.
7. Match the parts of a hydraulic system with the correct functions.
8. Arrange in order the steps in the operation of hydraulics.
9. List applications of hydraulic transmissions.

OBJECTIVE SHEET

10. Select advantages of hydraulic systems.

11. Identify connectors used in fluid power systems.

12. Distinguish between the two laws defining the principles of pneumatics.

13. Match parts of a pneumatic system with the correct functions.

14. List applications of pneumatics.

15. Match terms related to robotics with the correct definitions.

16. Distinguish between the two major categories of jobs in industry that are well suited for robots.

17. Complete statements concerning the principles of lasers.

18. Match classes of lasers with the correct descriptions.

19. List applications of lasers.

20. Match types of energy with examples of their storage devices.

21. Determine gear rotation. (Assignment Sheet #1)

22. Design and build a robotic arm. (Assignment Sheet #2)

23. Demonstrate the ability to:

    a. Build a "big track" robot. (Job Sheet #1)

    b. Build a lemon battery. (Job Sheet #2)

POWER TRANSMISSION AND STORAGE
UNIT IV

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparencies to enhance the information as needed.)

G. Provide students with job sheets.

H. Discuss and demonstrate the procedures outlined in the job sheets.

I. Integrate the following activities throughout the teaching of this unit:

    1. Show films dealing with power transmission and storage. Suggested films are listed on the next page.
    2. Arrange group tours to local manufacturing plant/s.
    3. Build a 90¢ continuity tester.
    4. Build a mousetrap vehicle to go along with gear rotation problems in Assignment Sheet #1.
    5. Make a block diagram showing TV waves in a transmission system.
    6. Add mechanical levers and/or electric motor to Assignment Sheet #2.
    7. Determine mechanical advantage of gears and levers.
    8. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Bohn, Ralph C. and Angus J. MacDonald. *Power: Mechanics of Energy Control.* Bloomington, IL: McKnight Publishing Co., 1983.

B. Bohn, Ralph C., et. al. *Energy, Power, and Transportation Technology.* Peoria, Illinois: Bennett & McKnight, 1986.

C. Grannis, Gary E. *Modern Power Mechanics.* Indianapolis, IN: Bobbs-Merrill, 1979.

D. Groneman, Chris H. and John L. Feirer. *General Industrial Education and Technology.* 7th ed. New York: McGraw-Hill, 1986.

E. *Hands on Robotics (for just $8) In Technology Activities: Idea Book 1* by Stern, Sam and Eugene F. Fichter, 21-22. Reston, VA: International Technology Education Association, 1986.

F. Hoekstra, Robert L. *Robotics and Automated Systems.* Cincinnati: South-Western Publishing Co., 1986.

G. *Laser Technology.* Compiled by Jerry Balistreri, Utah State Office of Education, 1985.

H. MacDonald, K. L. *Small Gasoline Engines — Student's Workbook.* 2nd ed. Indianapolis: Bobbs-Merrill Educational Publishing, 1982.

I. Pershing, Rex W. *Energy and Power.* Des Moines, IA: Department of Public Instruction, Career Education Division, 1980.

J. *Robotic Technology.* Compiled by Jerry Balistreri, Utah State Office of Education, 1985.

SUGGESTED SUPPLEMENTAL RESOURCES

Films:

A. *Studying Fluid Behavior* (Scientific Investigation Series); #04843; 16 min; color; (Journal), 1979; Bureau of Audiovisual Instruction; P.O. Box 2093; Madison, Wisconsin 53701-2093; or phone 608-262-1644.

B. *The Robot Revolution;* #11058; VHS; 58 min; Bureau of AV Instruction, Madison, Wisconsin 53701-2093; or phone 608-262-1644.

C. *Lasers: An Introduction;* #10555; 14 min; VHS; 1970; Bureau of AV Instruction, Madison, WI 53701-2093; or phone 608-262-1644.

D. *Electricity from Chemicals;* #06559; 14 min; color; Coronet, 1966; Bureau of Audiovisual Instruction, Madison, Wisconsin 53701-2093; or phone 608-262-1644.

E. *Electricity: the Way it Works;* #00478; 16 min; color; Electric Letter, 1978; Bureau of Audiovisual Instruction; P.O. Box 2093; Madison, Wisconsin 53701-2093; or phone 608-262-1644.

POWER TRANSMISSION AND STORAGE
UNIT IV

INFORMATION SHEET

I. **Terms and definitions**

   A. Accumulator — An auxiliary storage place for hydraulic fluid under pressure which is used to dampen out pulsations or pressure surges that cause vibrations and uneven operation of hydraulic devices

   B. Actuator — A fluid power device that changes fluid power to either rotary, linear, or reciprocating motion

   C. Hydraulics — The use of a liquid, usually oil, to transmit power

   D. Laser (**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation) — A device that generates a concentrated beam of light that travels in a very narrow straight path

   E. Pneumatics — The use of compressed gases, usually air, to transmit power

   F. Robot — Reprogrammable machine with an arm or hand that can pick up and move many things; may also be fitted with tools to perform other tasks

   G. Solid state — Electronic circuits using semiconductor devices such as, transistors, diodes, and silicon-controlled rectifiers

   H. Transformer — A device that transmits electrical power from one circuit to another

   I. Voltage — The electromotive force which will cause current to flow

II. **Types of power systems**

   A. Mechanical power — Uses gears, pulleys, and chains for control and transmission of mechanical energy

   B. Electrical power — Uses switches, relays, transformers, conductors, transmitters, and air for control and transmission of electric energy

   C. Fluid power — Uses liquids and gases under pressure for control and transmission of fluid energy

      1. Hydraulic — Fluid power using liquids (usually water or oil)

      2. Pneumatic — Fluid power using gases (usually air)

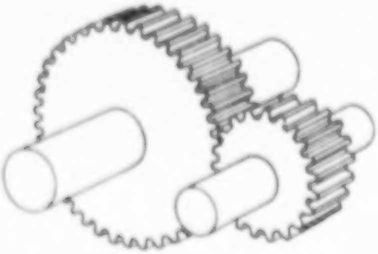
INFORMATION SHEET

III. **Devices for control and transmission of mechanical power** (Transparency 1)

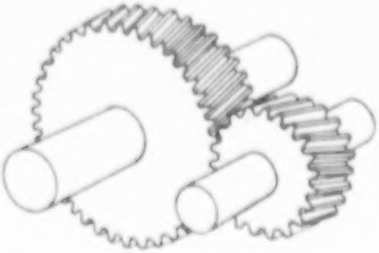
A. Gears — Are wheels that have teeth around their outside surface which mesh with the teeth of another gear.

(NOTE: The gear connected to the power source is called the drive gear. The second gear is called the driven gear.)

1. Spur gears — Simplest and most common type of gear. Teeth are cut parallel to shaft. Can provide changes in direction, force, or speed.

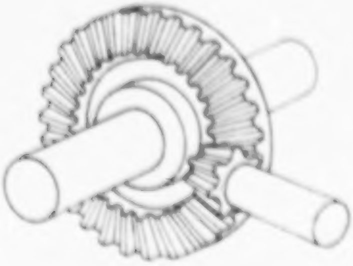


2. Helical gears — Similar to spur gears except that teeth are cut at an angle. Can change power direction. Pairs can be used in parallel or right-angle positions.

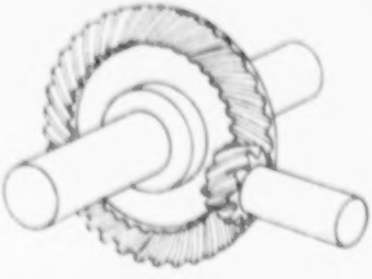


INFORMATION SHEET

3. Bevel gears — Used to change direction of power input or to increase force or speed when two different sizes of gears are used. May have straight or spiral-shaped (helical) teeth.



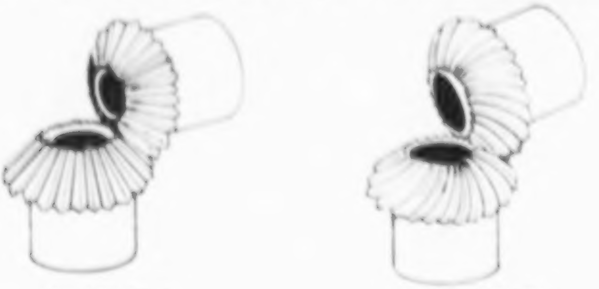
Plain Bevel



Spiral Bevel

(NOTE: Gears can increase or decrease the turning effort. They also may be used to change speed. When a slowdown is needed, reduction gears are used. Multiplying gears increases output speed.)

4. Miter gears — Can only provide changes in direction. Cannot change force or speed because both gears have the same number of teeth (gear ratio of 1:1). May have straight or spiral-shaped teeth.

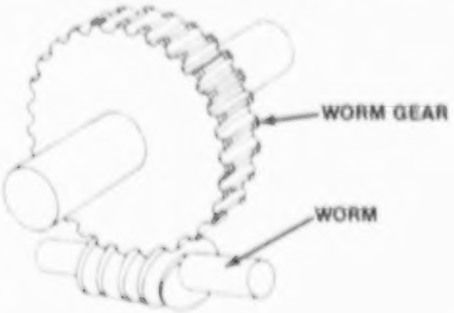


Straight Teeth

Spiral Teeth

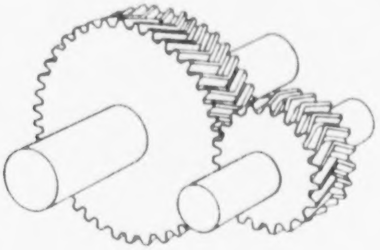
Miter Gear Sets

5. Worm gears — A set consists of a worm and a worm gear. Worm gear rotates only one tooth each time the worm makes a full rotation. Can provide major changes in torque and speed or a change in direction.

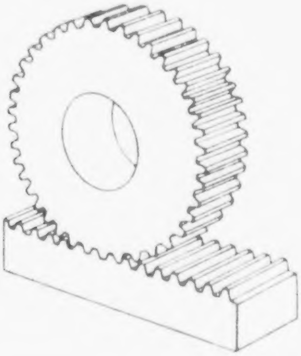


INFORMATION SHEET

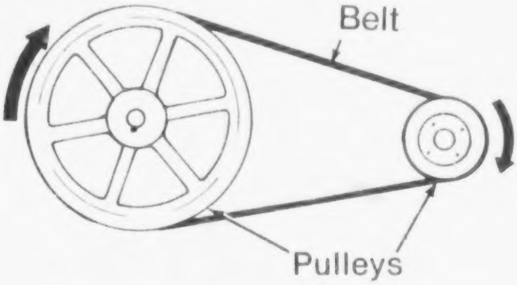
6. Herringbone gears — Are double helical gears with balanced thrusts because the teeth angles are reversed on opposite sides.



7. Rack and pinion gears — Provide a special type of gear arrangement which transfers straight-line motion into rotary motion or rotary motion into straight-line motion.

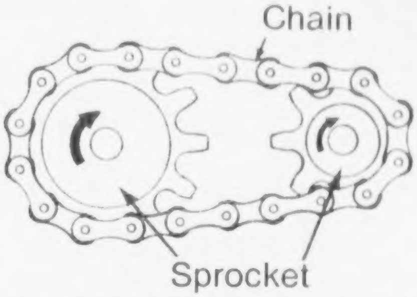


B. Pulleys and belts — Pulleys are usually metal grooved discs that drive or are driven by flexible belts. Mainly used to change force and speed.

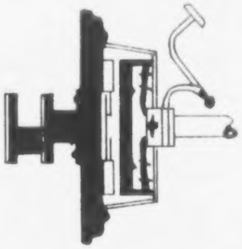


INFORMATION SHEET

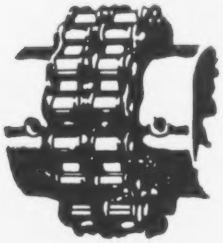
C. Sprockets and chains — Sprockets are similar to gears except that they drive or are driven by a chain instead of another gear. Can change force and speed. Do not change the direction of rotation as gears do.



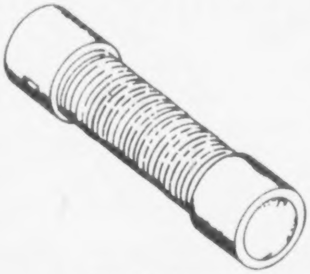
D. Clutches — Devices that connect or disconnect the flow of power from one unit to another. May be several types such as friction clutches and centrifugal clutches.



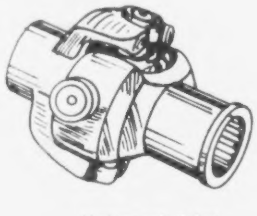
E. Couplings — Permanent connections used to change directions or to connect lengths of shafts. May be rigid or flexible.



Rigid Coupling



Flexible Coupling



Universal Joint

IV. **Transmission of electrical power** (Transparencies 2 and 3)

A. Transmission through solids — High voltage electricity generated at power plants is sent through transmission lines (conducting wires).

B. Transmission through air — Electromagnetic waves are sent through the air.

Examples: Television signals, radio signals, microwaves

INFORMATION SHEET

V. **Devices for control of electrical power** (Transparency 4)

   A. On-Off control devices (switches)

      1. Manual switch — Most common electrical control device

         Example: Common on-off light switch

      2. Relays — Used to control a circuit from a remote location

      3. Transistors — Solid-state devices used for switching and/or amplifying the flow of electrons in a circuit

   B. Directional and overload control devices

      1. Diodes — Permit current to flow in only one direction; solid state

      2. Fuses — Protect a circuit from dangerous overloads; must be replaced after use

      3. Circuit breakers — Have the same job as a fuse, but can be reset by hand after circuit is broken

   C. Current and voltage control devices

      1. Transformers — Allow current to be stepped up or down

      2. Resistors — Reduce current flow and control voltage drop

VI. **Principles of hydraulics**

   A. Pascal's Law — Pressure set up in a confined liquid acts equally in all directions.

   B. Liquid cannot be compressed.

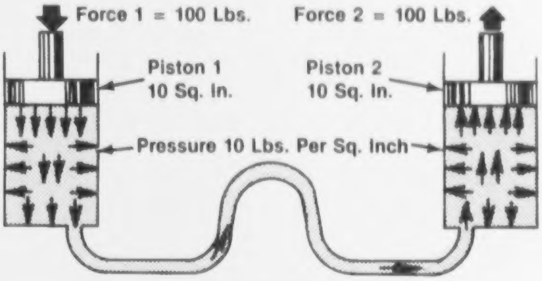
   C. Liquid can be used to transmit power.

   D. Liquid can be used to multiply force.

INFORMATION SHEET

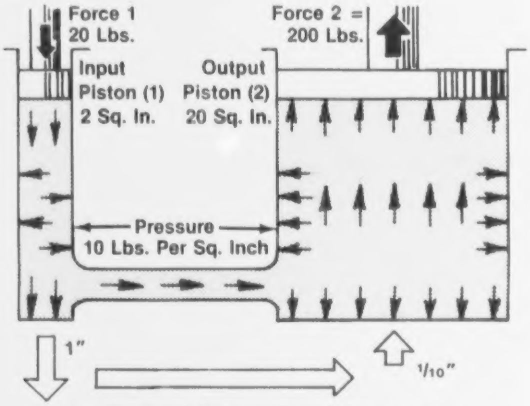
E. Applications of these principles

1. If the input and output pistons have equal areas and equal pressures, the output force will be equal to the input force.


Force 1 = 100 Lbs.
Force 2 = 100 Lbs.
Piston 1
10 Sq. In.
Piston 2
10 Sq. In.
Pressure 10 Lbs. Per Sq. Inch

Equal Area + Equal Pressure = Equal Force

2. If the input and output pistons have unequal areas and equal pressures, the input and output forces will be unequal.


Force 1
20 Lbs.
Force 2 =
200 Lbs.
Input
Piston (1)
2 Sq. In.
Output
Piston (2)
20 Sq. In.
Pressure
10 Lbs. Per Sq. Inch
1"
1/10"

Unequal Area + Equal Pressure = Unequal Force

VII. **Parts of a hydraulic system** (Transparency 5)

A. Motor, turbine, or engine — Drives the pump

B. Pump — Supplies fluid under pressure to system

C. Reservoir or tank — Stores the fluid

INFORMATION SHEET

D. Filter — Cleans the fluid

E. Pressure relief valve — Opens to relieve excess pressure and to prevent damage to both the system and the surroundings

F. Control valve — Regulates fluid pressure, flow rate, and direction of flow

(NOTE: Most systems have several control valves, each with specific purposes.)

G. Cylinder — Transfers fluid pressure in system to piston which pushes load; changes fluid pressure into mechanical motion

VIII. **Operation of hydraulics**

A. Oil pump draws the oil from the reservoir.

B. Oil passes to the chambers of a control valve.

C. Oil is directed to double-acting cylinders.

D. Hydraulic pressure causes the piston to move and perform work.

IX. **Applications of hydraulic transmissions**

A. Automotive — Power brakes, power windows, automatic transmissions, power steering, shock absorbers

B. Manufacturing — Machine tools, food and chemical processors, plastics, presses, loaders

C. Aerospace — Aircraft, landing gears, helicopters, satellites

D. Agriculture — Automatic bale loaders, machinery hoists, tractors, grain beds, pickers, threshers

E. Construction — Road graders, shovels, rock crushers, bulldozers

X. **Advantages of hydraulic systems**

A. Are simple having no gears or levers

B. Require no lubrication

C. Liquids are not subject to wear or breakage.

D. Applied forces can be multiplied and transmitted in any direction and over considerable distance with little loss in efficiency.

E. Transmitted motion is smooth and consistent.

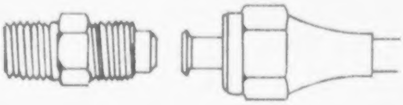
F. Closed or sealed system prevents entry of dirt and resulting wear.

INFORMATION SHEET

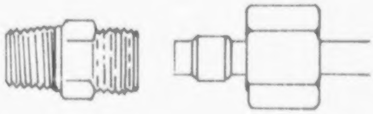
XI. Connectors used in fluid power systems

(NOTE: Connectors are a very important part of transmission lines. They are used to join the different parts of a fluid system.)

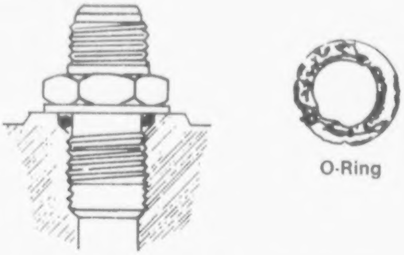
A. Flared tube fitting



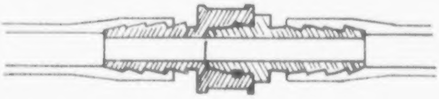
B. Compression sleeve fitting



C. Fitting with O-ring seal



D. Quick-disconnect fitting with barbed fasteners



XII. Principles of pneumatics

A. Boyle's law — If the volume of air or gas in a cylinder is compressed to one-half of its original volume, its pressure will double.

B. Charles' law — When the volume of a gas remains constant and its temperature increases, the pressure increases proportionally.

Example: A sealed can will explode if it is heated sufficiently.

INFORMATION SHEET

XIII. **Parts of a pneumatic system** (Transparency 5)

- A. Motor or engine — Drives the air compressor
- B. Air compressor — Increases the pressure of the air or gas
- C. Pressure relief valve — Opens to relieve excess pressure
- D. Filter — Removes dirt from the air
- E. Regulator — Monitors and controls the desired air pressure in the line
- F. Lubricator — Adds some oil to the air passing through and reduces friction between sliding surfaces
- G. Control valves — Regulate flow rate and direction of air
- H. Cylinder or other actuator — Converts pressure into mechanical motion

XIV. **Applications of pneumatics**

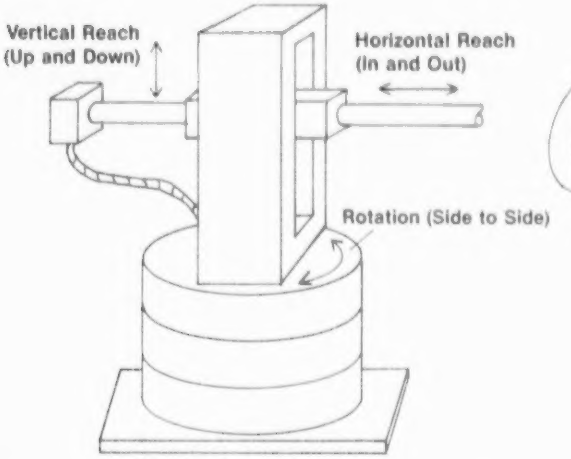
(NOTE: These are just a **few** of the many applications of pneumatics.)

- A. Aerosol-powered liquids — Spray paint
- B. Die casting — Forcing molten metal into molds
- C. Forging — Shaping hard-to-work metal
- D. Aerospace — Engine control units to correct yaw and pitch
- E. Transportation — Tires and brake systems
- F. Pneumatic tools — Air drills, staplers, riveting guns

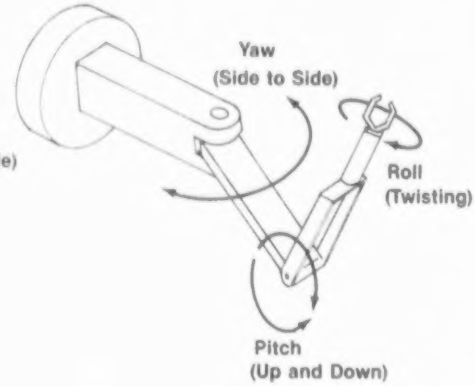
INFORMATION SHEET

XV. **Robotics terminology** (Transparency 6)

A. Axes — The number of rotary center points on which motion is performed; may have 1-6 axes


Vertical Reach
(Up and Down)
Horizontal Reach
(In and Out)
Rotation (Side to Side)

3 Major Axes

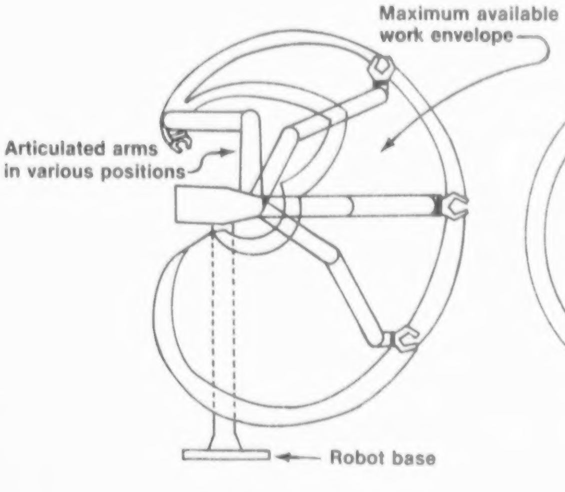

Yaw
(Side to Side)
Roll
(Twisting)
Pitch
(Up and Down)

3 Minor Axes

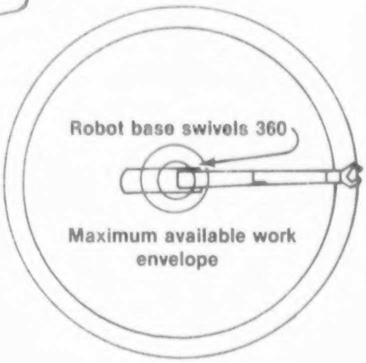
From *Robotics and Automated Systems* by Robert L. Hoekstra. Published by South-Western Publishing Co., ©1986.

B. Controller — Part of the robot that directs the motion of the robot's manipulator

C. Envelope — The working area of the robot


Maximum available
work envelope
Articulated arms
in various positions
Robot base

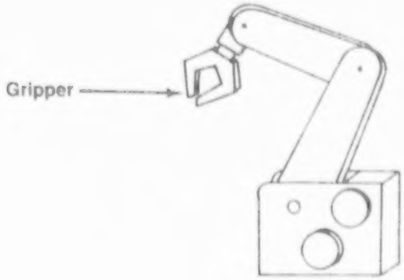
Side View


Robot base swivels 360
Maximum available work
envelope

Top View

INFORMATION SHEET

D. Gripper — A handlike, pinching device that holds the part being moved or worked on or the tools doing the work



E. Manipulator (arm) — Part of the robot that is programmed to move and to pick up and place parts or hold tools for work procedures

F. Power supply — Supplies hydraulic, pneumatic, or electric power to move the manipulator

XVI. Jobs well suited for robots

A. Hazardous jobs — Tasks that are dangerous or harmful to humans because of toxic fumes, temperature or weight of the material being handled, high levels of radiation, or danger working near rotating machinery

B. Repetitive jobs — Tasks that must be performed hundreds of times each day

(NOTE: A robot can perform these jobs without fatigue or boredom which helps to increase company productivity.)

XVII. Principles of lasers

A. Laser beams consist of electromagnetic waves at or near the wavelength of visible light.

B. The waves in a laser have almost identical lengths enabling it to travel in a straight line for miles with very little spreading.

C. Laser wavelengths are very short and are measured in millionths of an inch.

(NOTE: Radio wavelengths are measured in yards, and television wavelengths are measured in feet.)

INFORMATION SHEET

XVIII. **Classes of lasers**

A. Class I — Produce low powered light; cannot cause damage to anyone or anything

B. Class II — Can damage the eye only if the eye is deliberately exposed to the beam for periods of time longer than the normal blinking of the eye

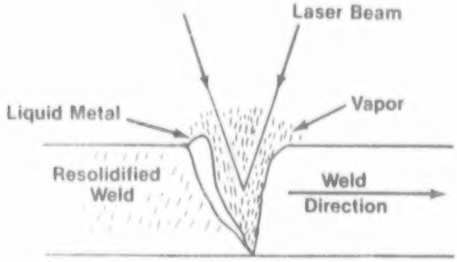
C. Class III — Can produce light of high enough intensity to injure a human eye before the eye can blink

D. Class IV — Are a potential hazard to the eye and to exposed skin; can produce enough light energy to burn any combustible material

XIX. **Applications of lasers**

A. In communications, lasers are used with fiberoptics to transmit telephone conversations.

B. In industry, lasers are used to drill holes and braze or weld metals.



C. In medicine, lasers are used to cut tissue and then seal tissues together so stitches are not needed.

D. In construction, lasers are used with surveying equipment for more accurate measurements of distances and elevations.

E. In consumer products, lasers are used to scan items in supermarket checkouts and video disks readers.

XX. **Types of energy storage**

A. Mechanical energy

1. Spring — The stored potential energy in a "loaded" spring (one that's stretched or compressed) can be recovered to do useful work.
2. Flywheel -- A rotating flywheel stores energy that can be removed to do work.

INFORMATION SHEET

B. Electrical energy

1. Capacitors — Store and discharge energy in an electrical system over long periods of time
2. Inductor — Concentrate and store magnetic lines of force

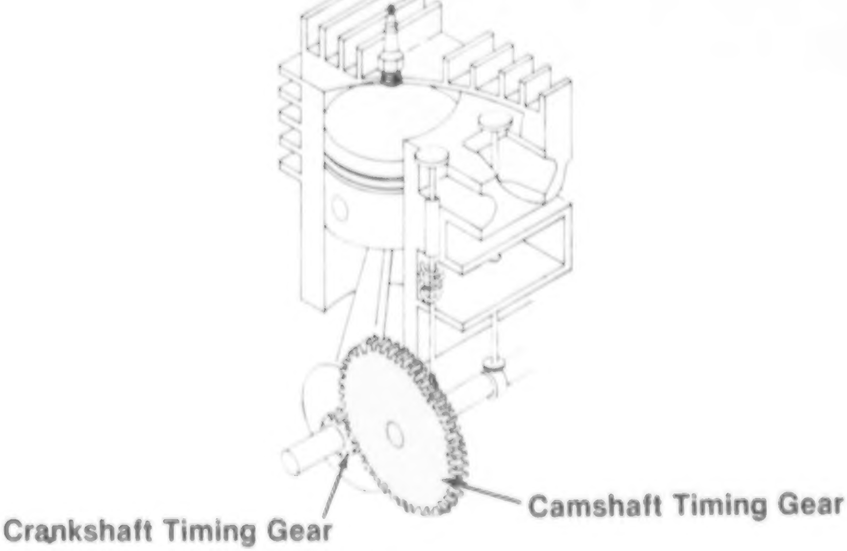
C. Chemical energy

1. Fossil fuels — Oil, coal, and natural gas are all chemicals or combinations of chemicals stored until released by burning.
2. Battery — A device that converts stored chemical energy into electrical energy.

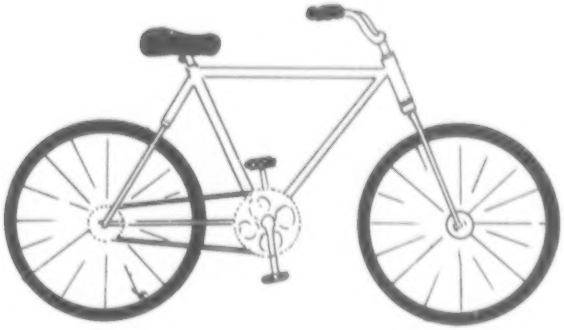
D. Fluid energy

1. Air tank (compressed air) — Potential energy stored in compressed air can be released as kinetic energy to produce work.
2. Accumulator (oil) — A sealed tank that holds fluid under pressure as potential energy which can be released on demand.

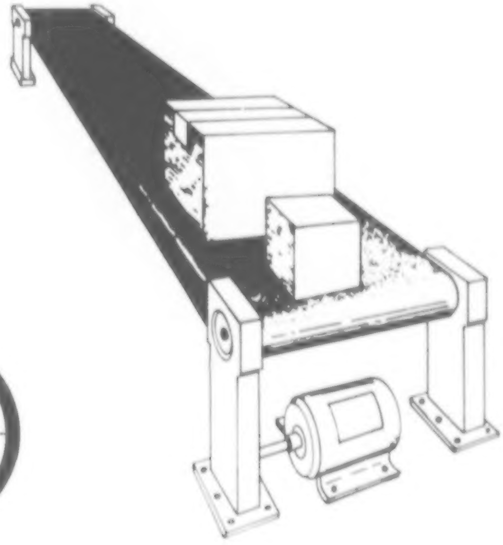
Mechanical Power Transmissions


Crankshaft Timing Gear
Camshaft Timing Gear

Gears

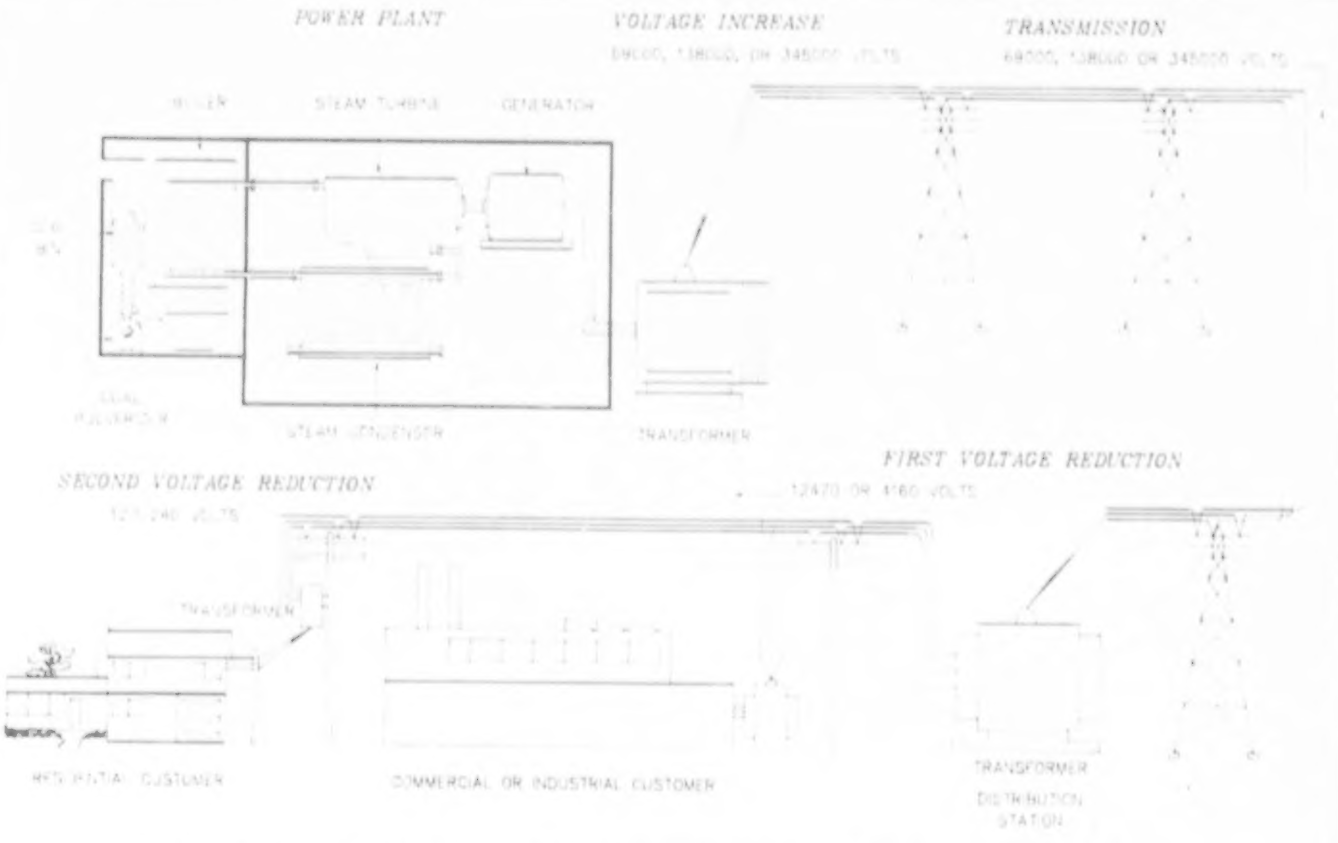


Sprocket and Chain



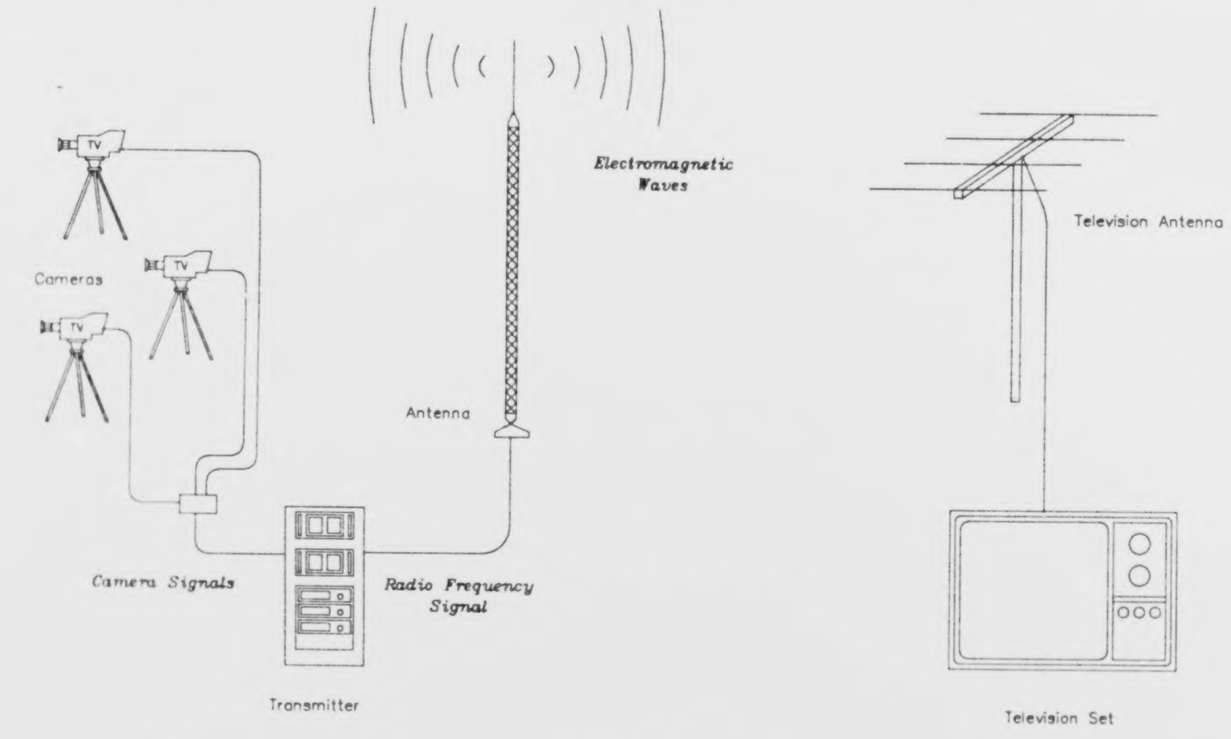
Pulleys and Belt

Electrical Power Transmission Through Solids


POWER PLANT
VOLTAGE INCREASE
69000, 138000, OR 345000 VOLTS
TRANSMISSION
69000, 138000 OR 345000 VOLTS
BOILER
STEAM TURBINE
GENERATOR
COAL PULVERIZER
STEAM CONDENSER
TRANSFORMER
FIRST VOLTAGE REDUCTION
12470 OR 4160 VOLTS
SECOND VOLTAGE REDUCTION
120-240 VOLTS
TRANSFORMER
RESIDENTIAL CUSTOMER
COMMERCIAL OR INDUSTRIAL CUSTOMER
TRANSFORMER
DISTRIBUTION STATION

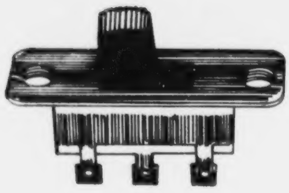
Electrical Power Transmission Through Solids

Electrical Power Transmission Through Air


TV
TV
TV
Cameras
Camera Signals
Transmitter
Radio Frequency Signal
Antenna
Electromagnetic Waves
Television Antenna
Television Set

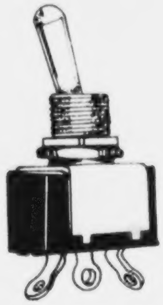
Electrical Power Transmission Through Air

Electrical Power Control Devices

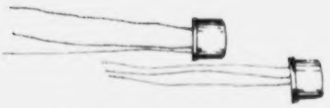


Slide Switch

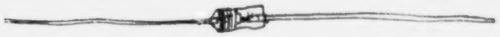
Switches



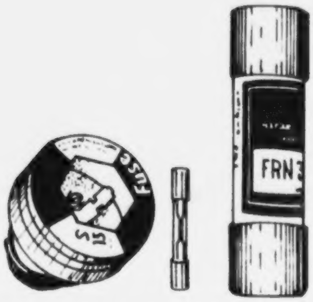
Toggle Switch



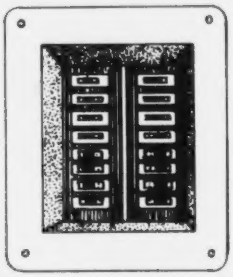
Transistors



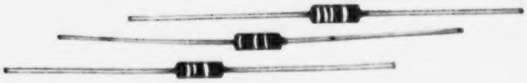
Diode



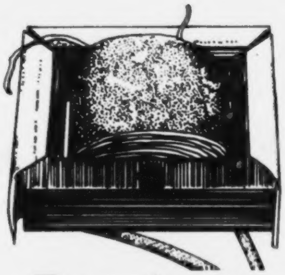
Fuses



Circuit Breaker

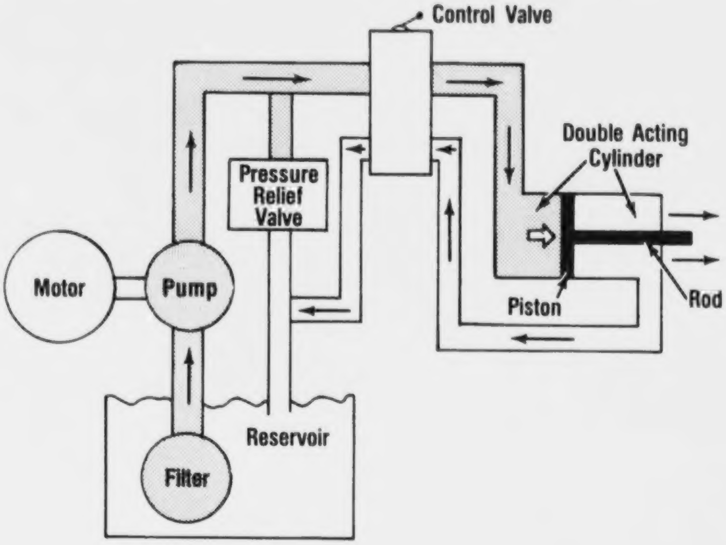


Resistors

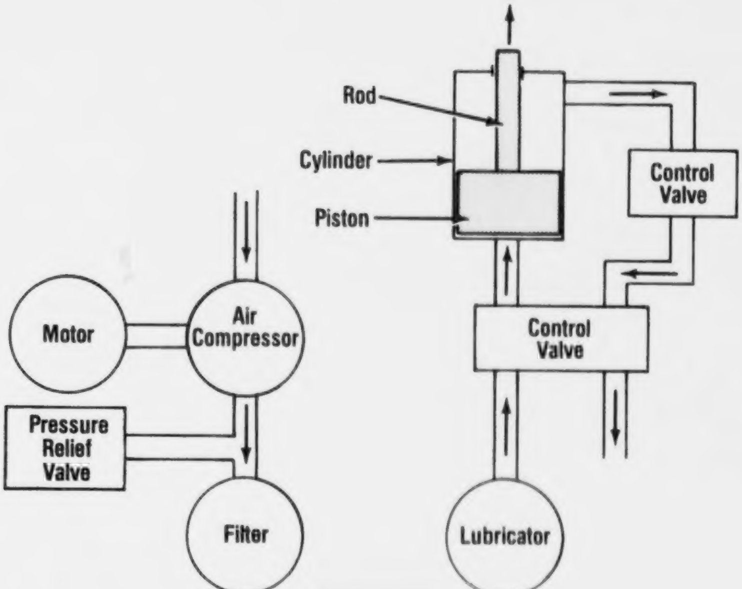


Transformer
(Iron Core)

Fluid Power Systems

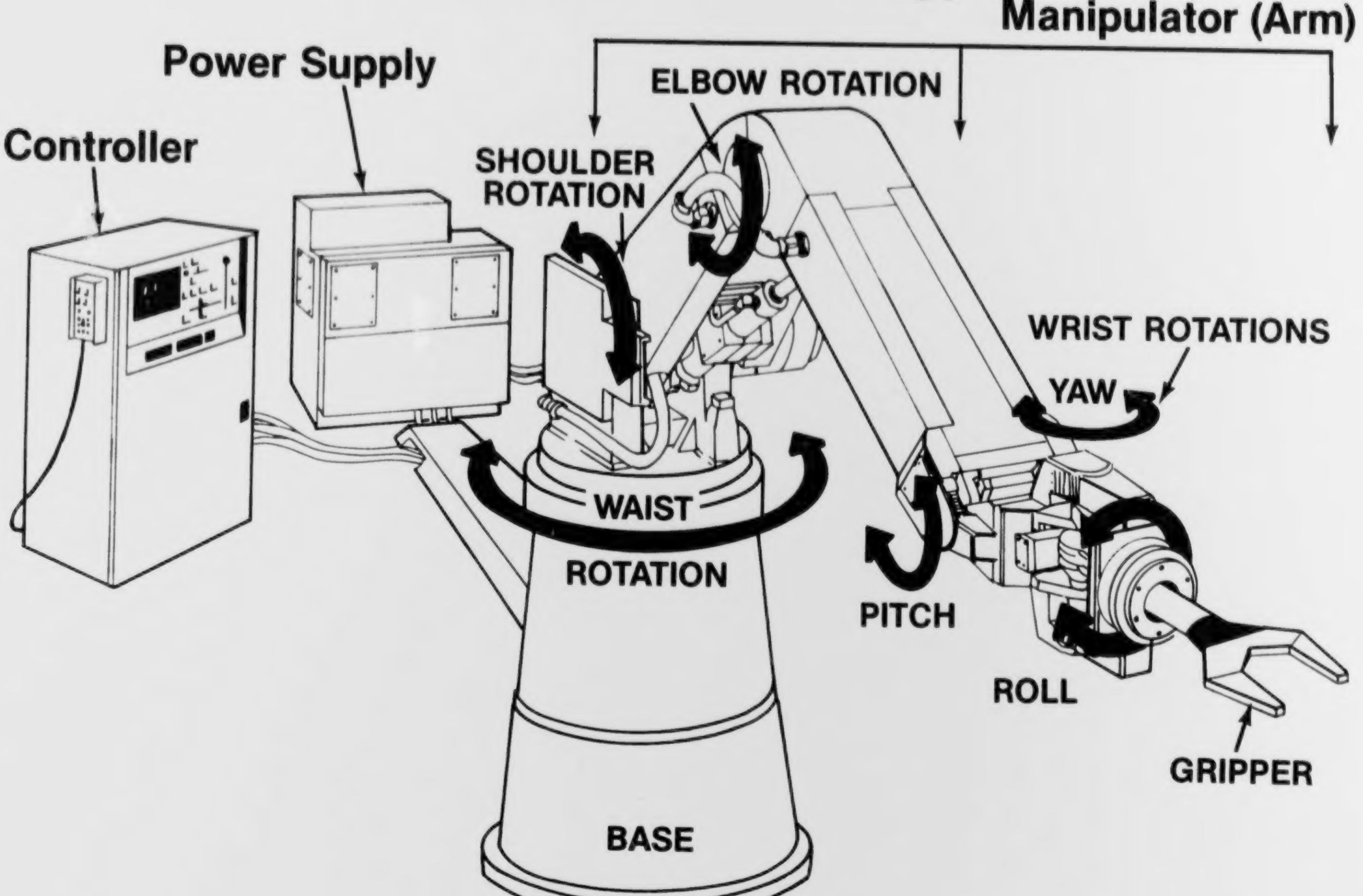

Control Valve
Double Acting
Cylinder
Pressure
Relief
Valve
Motor
Pump
Piston
Rod
Reservoir
Filter

Simple Hydraulic System


Rod
Cylinder
Piston
Control
Valve
Motor
Air
Compressor
Control
Valve
Pressure
Relief
Valve
Filter
Lubricator
Regulator

Simple Pneumatic System

Robotics Terminology


Manipulator (Arm)
Power Supply
Controller
ELBOW ROTATION
SHOULDER ROTATION
WRIST ROTATIONS
YAW
WAIST
ROTATION
PITCH
ROLL
GRIPPER
BASE

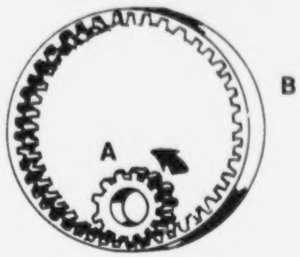
POWER TRANSMISSION AND STORAGE
UNIT IV

ASSIGNMENT SHEET #1 — DETERMINE GEAR ROTATION

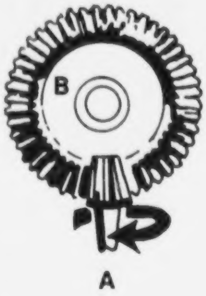
NAME ______________________________ SCORE ____________

Directions: In the illustrations below, the direction of rotation of gear "A" is given. Draw an arrow to indicate the direction of rotation of the other gears.

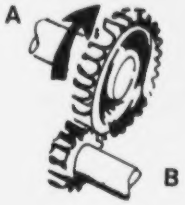
1.



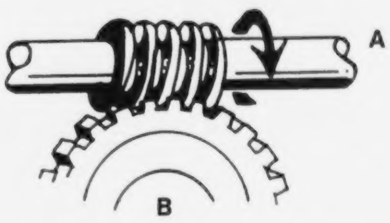
2.



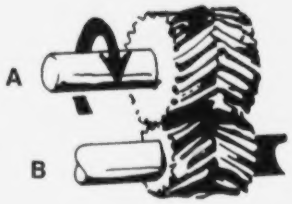
3.



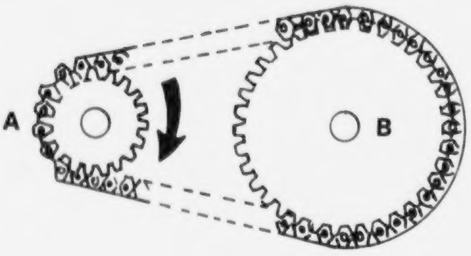
4.



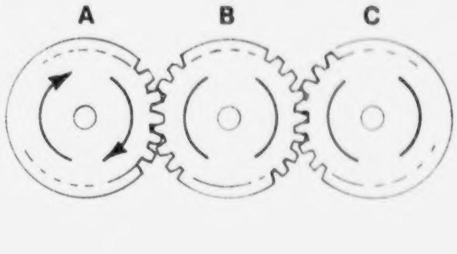
5.



6.



7.



POWER TRANSMISSION AND STORAGE
UNIT IV

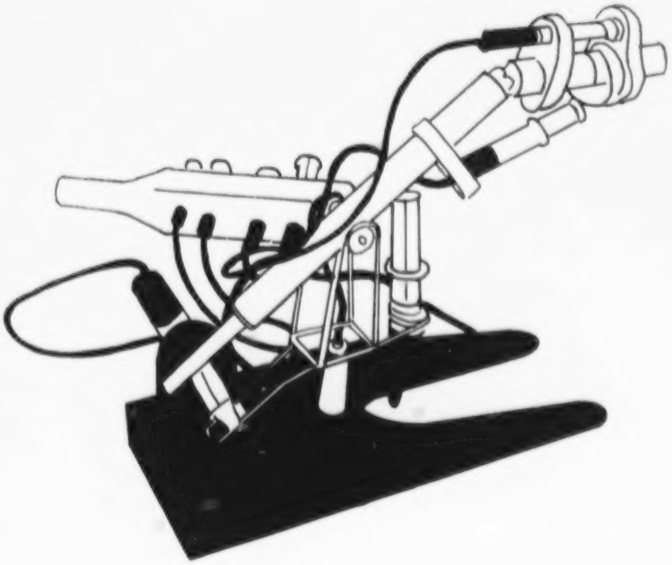
ASSIGNMENT SHEET #2 — DESIGN AND BUILD A ROBOTIC ARM

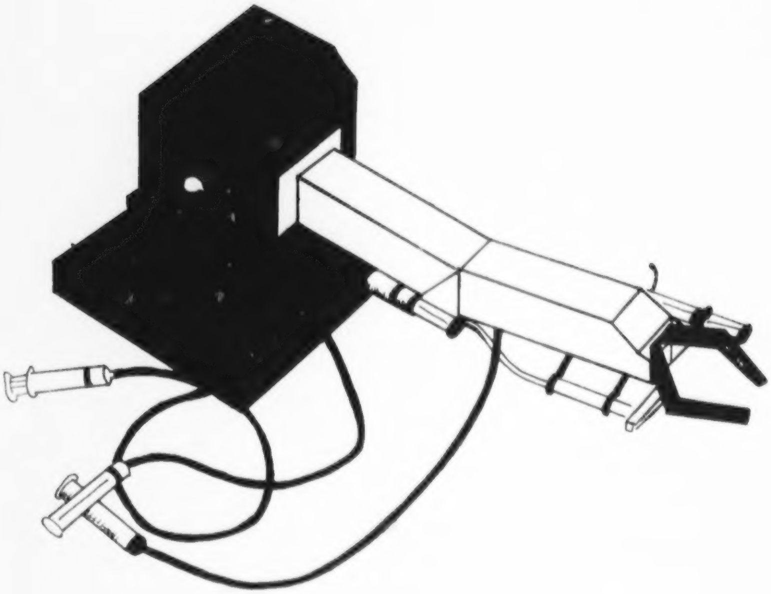
NAME ______________________________ SCORE ____________

1. This exercise demonstrates the principles of hydraulics using syringes and tubing.
2. Discuss the ways this system could be used to make a robot with one, two, three, four, or more axes.
3. Plan to use basic materials, traditional tools, and techniques to produce a well-designed robot that teaches math and science principles as well as craftsmanship.
4. There are no detailed plans with this activity in order to allow freedom of creativity.
5. The specific dimensions are not important.
6. Syringes used in robot construction are one to sixty cubic centimeters (cc).
7. Tubing is 1/8" tubing and can be purchased from local hardware store.
8. Look at the following pictures. Then sketch your ideas and plan your robotic arm.
9. In building this robotic arm, observe your lab/classroom's safety rules.
10. In designing your robotic arm, use different types of power systems: mechanical, electrical, and fluid.

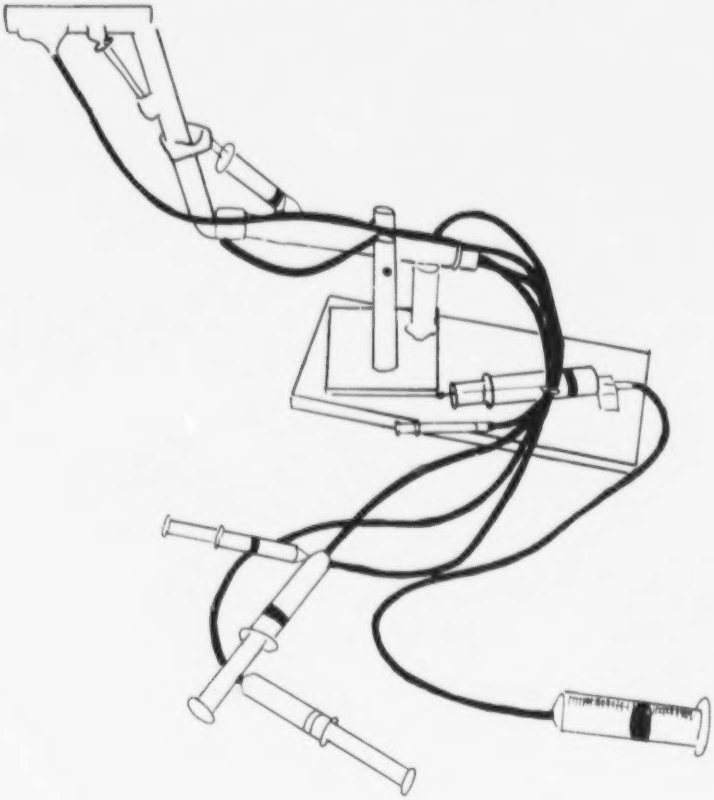
ASSIGNMENT SHEET #2

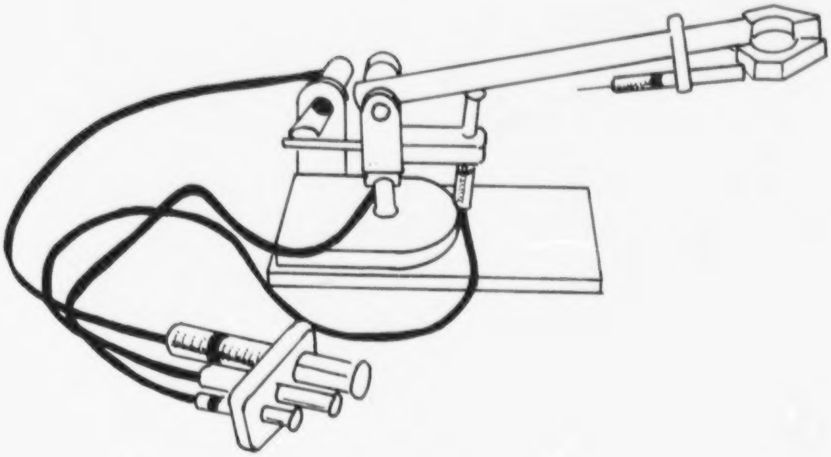
Examples:



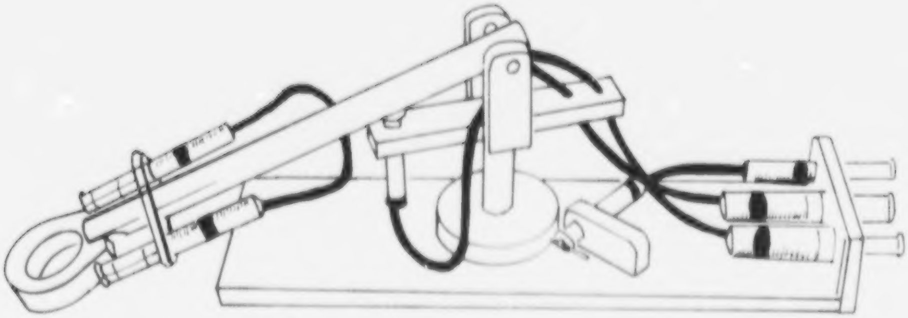


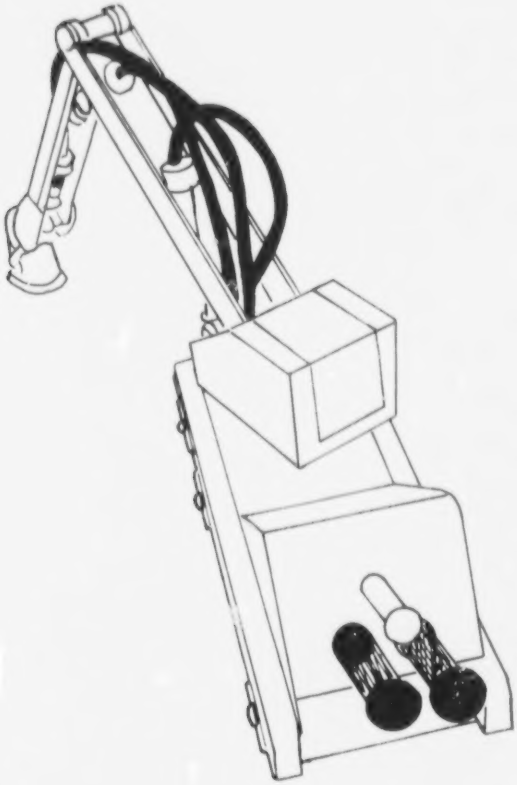
ASSIGNMENT SHEET #2





ASSIGNMENT SHEET #2



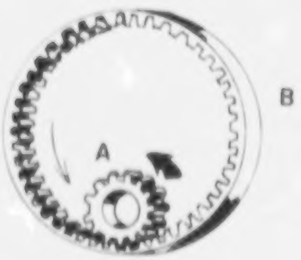


POWER TRANSMISSION AND STORAGE
UNIT IV

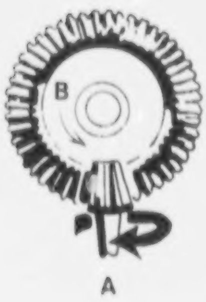
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

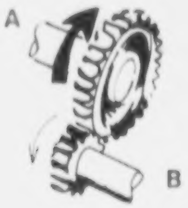
1.



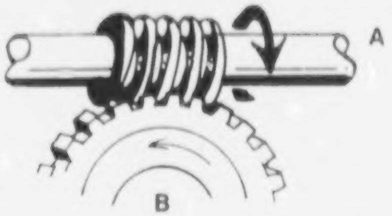
2.



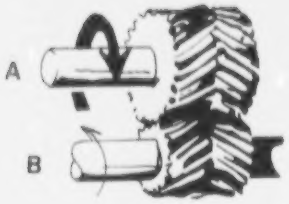
3.



4.



5.



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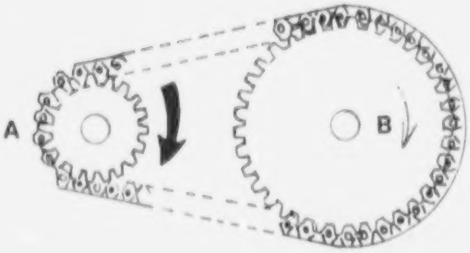

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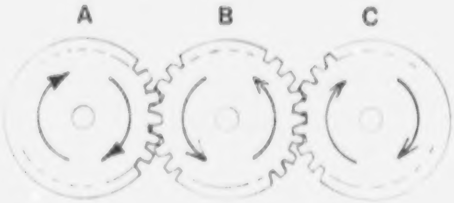


Assignment Sheet #2 — Evaluated to the satisfaction of the instructor

POWER TRANSMISSION AND STORAGE
UNIT IV

JOB SHEET #1 — BUILD A "BIG TRACK" ROBOT

A. Tools and materials

1. 2 - 1" sections of 8-32 threaded rod with nuts (to mount wheels)
2. 1 - 6-32 machine screw, nut, and washer (to mount battery switches)

   (NOTE: The length of screw needed will depend on the size of battery switches used.)
3. 1 - #8 × 1/2 inch RH wood screw (for negative battery terminal)
4. 4 - 4 penny finishing nails (for connection terminals)
5. 2 - 5/8 inch box nails (to connect skid block to strap)
6. 1 - 1/2 inch furniture glide (for skid)
7. 1 - 2 1/2 × 3/8 × 1/16 inch strap of metal or plastic (for skid block)
8. 1 - 1 1/4 × 3/8 × 0.005 inch brass shim (for battery switch)
9. 1 - 1 3/4 × 3/4 × 2 1/2 inch wood skid block
10. 1 - 1 1/8 inch diameter × 1 inch wood dowel (for battery holder bottom)
11. 1 - 1 1/8 inch inside diameter × 5 inch plastic tube (for battery holder)
12. 16 feet of #30 wire-wrap wire
13. Foam tape (for tires)
14. Masking tape (to make wire into cable)
15. 2 - Wheel discs between 3" and 5" diameter of plastic, wood, or metal

    (NOTE: Mini Frisbees or plastic coasters work well.)
16. 2 - DPDT momentary contact switches
17. Epoxy
18. 2 - "C" size dry cell batteries

JOB SHEET #1

19. "BIG TRACK" motor assembly

(NOTE: Known sources of supply are:

H & R Corporation
401 E. Erie Avenue
Philadelphia, PA 19134
(Surplus electrical and mechanical equipment, BIG TRACK motors)

Edmund Scientific Co.
101 E. Gloucester Pike
Barrington, NJ 08007
(Variety of supplies including some surplus BIG TRACK motors)

Marlin P. Jones & Associaties
P.O. Box 12685
Lake Park, FL 33403
(Surplus electronics)

JERRYCO Inc.
601 Linden Place
Evanston, IL 60202
(Surplus electronic and mechanical equipment)

B. Procedure

1. Check motors and connections in BIG TRACK motor unit with a multimeter.

   (NOTE: The winding resistance is about 4 ohms. It may be necessary to rotate the motor shaft to get a true reading.)

2. Slip sections of 8-32 threaded rod inside tubing axles on BIG TRACK motor unit.

   (NOTE: If the inside diameter of the axle is too small, it can be enlarged with a 11/32 drill.)

3. Glue threaded rod into axle with epoxy.

4. Cut plywood disks if using wooden wheels, with a fly cutter.

   (NOTE: If wooden wheels are used, foam tape can be added to outer surface to provide better traction.)

5. Drill center holes in wheel disks.

   (NOTE: A corner jig on a drill press may make it easier for students to accurately center holes.)

6. Cut 1 1/8" plastic tubing into 5" length.

7. Cut 1" wooden plug from 1 1/8" dowel.

8. Drill hole in plug to pass wire through.

9. Drive brass screw into one end of plug, holding wire end under it.

10. Test connection with multimeter.

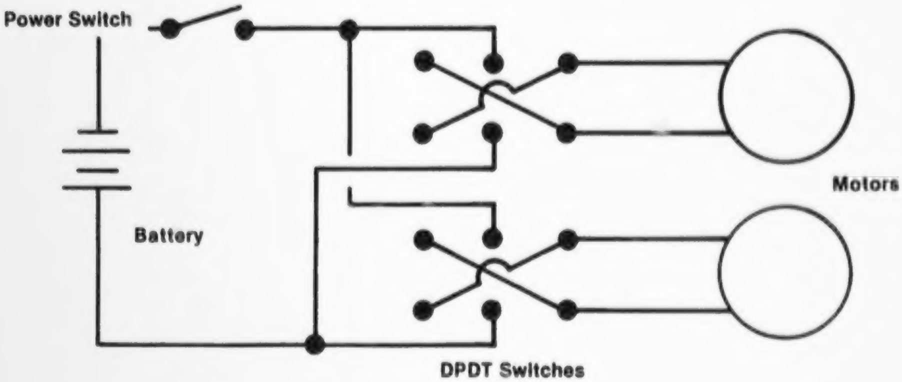
JOB SHEET #1

11. Push plug into the end of plastic tube.
12. Secure by driving two 1/2" nails in, taking care not to drive nails through wire.
13. Punch 1/8" hole in brass shim stock about 1/4" from the end.
14. Punch another 1/8" hole 1/4" from the end of the plastic tube.
15. Fasten together tube, shim stock, and wire with a 6-32 inch screw, nut, and washer.
16. Test connections with a multimeter.
17. Tape together wires from battery terminals about every 6 inches to form a cable.
18. Mark screw holes in strap for mid-line attachment at two screws nearest the motors.
19. Drill holes in strap.
20. File out side of strap to accommodate bulges in motor housing between screws.
21. Drill two holes in strap to nail strap to wooden block.
22. Drive furniture glide into one side of wooden block.
23. Mount connectors from motor wires to control cable on opposite side of wood block.
24. Drive in 4 penny finishing nails to connect motor wires to cable, in pattern that matches motor wires.
25. Cut off nail heads after driving them in.
26. Nail strap onto block.
27. Strip 1/2" of insulation from each end of four 5′ pieces of wire-wrap wire.
28. Wrap one end of wire to each of four nails in skid assembly block.
29. Solder each wire to nail.
30. Attach motor leads to nails.
31. Mark each free end of wire attached to nail so it can be identified with motor lead to which it is attached.
32. Tape wires every 6" to form cable.

JOB SHEET #1

33. Check connections with multimeter.
34. Remove spring locks from (2) DPDT switches.
35. Connect switches as shown. (Figure 1)

FIGURE 1


Power Switch
Battery
Motors
DPDT Switches

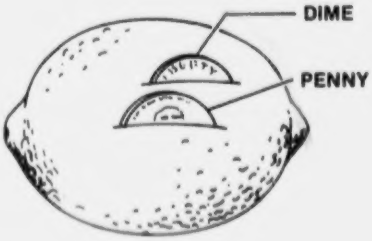
36. Put 2 "C" dry cell batteries in case.
37. Test "Big Track" robot.
38. Field test robot by running it through an obstacle course.

POWER TRANSMISSION AND STORAGE
UNIT IV

JOB SHEET #2 — BUILD A LEMON BATTERY

A. Tools and materials

1. Galvanometer
2. Knife
3. Lemon
4. Penny
5. Nickle or dime
6. Fine abrasive paper
7. Hookup wire



B. Procedure

1. Make two small slits in the lemon (1 cm long, 1 cm deep, 2 cm apart).
2. Clean both sides of the two coins thoroughly using the fine abrasive paper.
3. Insert the two coins into the two slits so that both stick out a little bit.
4. Attach one galvanometer lead to the dime.
5. Read the meter. What does it read? ______________
6. Attach the other lead to the penny.
7. Read the meter again. What does it read now? ______________

POWER TRANSMISSION AND STORAGE
UNIT IV

PRACTICAL TEST
JOB SHEET #1 — BUILD A "BIG TRACK" ROBOT

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:		YES	NO
1.	Checked out proper tools and materials.	______	______
2.	Checked motors and connections on "Big Track" unit.	______	______
3.	Glued threaded rod into axles.	______	______
4.	Cut and drilled holes in wheels.	______	______
5.	Assembled battery case.	______	______
6.	Assembled skid and motor unit assembly.	______	______
7.	Assembled cable.	______	______
8.	Assembled switch.	______	______
9.	Checked in/put away tools and materials.	______	______
10.	Cleaned the work area.	______	______
11.	Used proper tools correctly.	______	______
12.	Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13.	Practiced safety rules throughout procedure.	______	______
14.	Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Axles	Glued securely accurately	Positioned satisfactorily	Not enough epoxy for secure fit	Too much epoxy/Wheels won't mount
	4	3	2	1
Wheels	Round/Center holes drilled accurately	Slightly out of round/center hole accurate	Out of round/center accurate	Out of round/center hole off
	4	3	2	1
Battery case	Proper length/ Plug fits well	Proper length/ Plug slightly off	Case too long/ Plug slightly off	Case too short/ Plug off
	4	3	2	1
Skid and Motor Unit	Skid attached properly to motor unit	Skid attachment needs minor adjustment	Skid attachment needs major adjustment	Attachment needs to be redone
	4	3	2	1
Cable	Proper length/ Connections check OK	Cable too long/ Connections OK	Cable too short/ Connections OK	Cable too short/ Connections don't check out
	4	3	2	1
Switch	Work properly	Wiring needs minor adjustment	Wiring needs major adjustment	Switches won't work

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.

3 — Moderately skilled — Has performed job during training program; limited additional training may be required.

2 — Limited skill — Has performed job during training program; additional training is required to develop skill.

1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

POWER TRANSMISSION AND STORAGE
UNIT IV

PRACTICAL TEST
JOB SHEET #2 — BUILD A LEMON BATTERY

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Made slits in the lemon.	______	______
3. Cleaned both sides of the coin.	______	______
4. Inserted the coins in the lemon.	______	______
5. Attached one galvanometer lead to dime.	______	______
6. Read meter.	______	______
7. Attached other lead to the penny.	______	______
8. Read meter.	______	______
9. Checked in/put away tools and materials.	______	______
10. Cleaned the work area.	______	______
11. Used proper tools correctly.	______	______
12. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
13. Practiced safety rules throughout procedure.	______	______
14. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #2 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Cut slits in lemon	Correct size slits	Slits too small	Slits too long	Slits too deep
	4	3	2	1
Cleaned coins	Cleaned thoroughly	Some cleaning required	Require more cleaning	Coins not cleaned
	4	3	2	1
Inserted coins	Inserted correctly	Coins need minor adjustment	Coins too shallow	Coins below surface

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

POWER TRANSMISSION AND STORAGE
UNIT IV

NAME ____________________ SCORE ____________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. A device that transmits electrical power from one circuit to another

_____b. The electromotive force which will cause current to flow

_____c. An auxiliary storage place for hydraulic fluid under pressure which is used to dampen out pulsations or pressure surges that cause vibrations and uneven operation of hydraulic devices

_____d. Reprogrammable machine with an arm or hand that can pick up and move many things; may also be fitted with tools to perform other tasks

_____e. A fluid power device that changes fluid power to either rotary, linear, or reciprocating motion

_____f. Electronic circuits using semiconductor devices such as transistors, diodes, and silicon-controlled rectifiers

_____g. The use of a liquid, usually oil, to transmit power

_____h. A device that generates a concentrated beam of light that travels in a very narrow straight path

1. Accumulator
2. Actuator
3. Hydraulics
4. Laser
5. Pneumatics
6. Robot
7. Solid state
8. Transformer
9. Voltage

2. Distinguish between types of power systems by placing an "E", "M", or "F" in front of the correct descriptions of **electrical, mechanical,** or **fluid** power systems.

_____a. Uses gears, pulleys, and chains for control and transmission of energy

_____b. Uses liquids and gases under pressure for control and transmission of energy

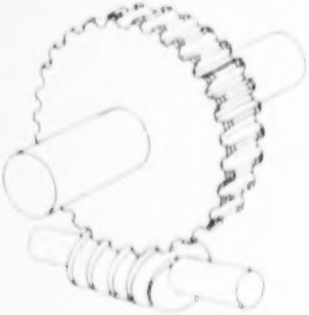
_____c. Uses switches, relays, transformers, conductors, transmitters, and air for control and transmission of energy

TEST

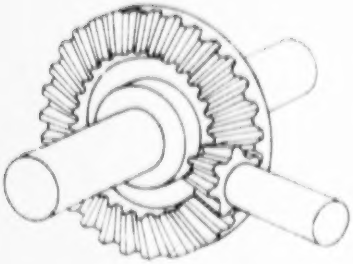
3. Identify devices for control and transmission of mechanical power by placing the appropriate number beside each picture.

1. Belt and pulley
2. Bevel gear
3. Chain and sprocket
4. Clutch
5. Couplings
6. Helical gear
7. Herringbone gear
8. Miter gear
9. Rack and pinion gear
10. Spur gear
11. Worm gear

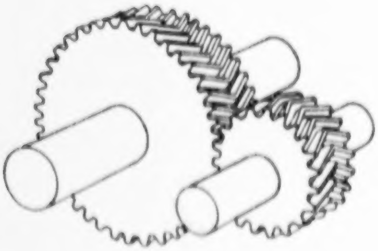
_____a.



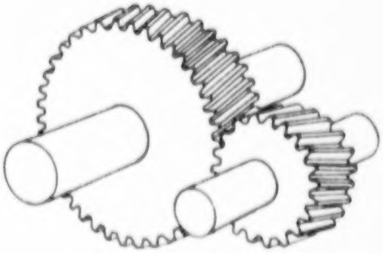
_____b.



_____c.

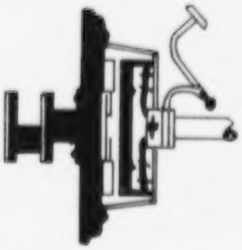


_____d.

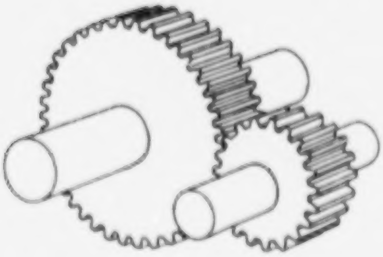


TEST

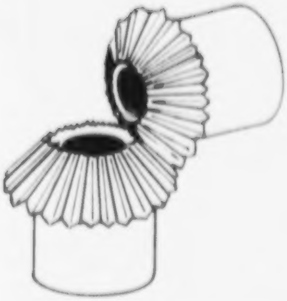
_____e.



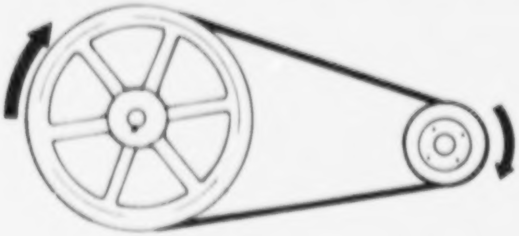
_____f.



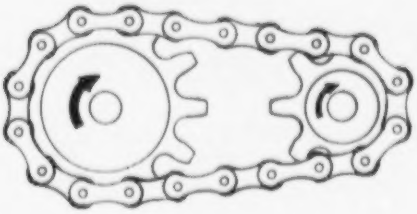
_____g.



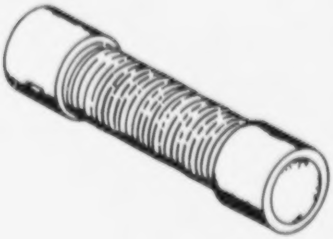
_____h.



_____i.

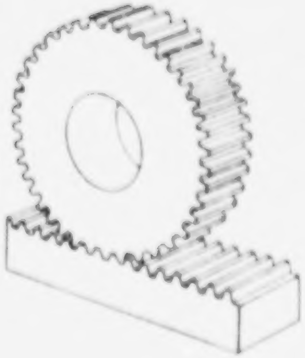


_____j.



TEST

______k.



4. Complete the following statements concerning the transmission of electrical power by circling the correct words.

   a. Transmission through solids is (**low, high**) voltage electricity generated at power plants sent through transmission lines.

   b. Transmission through air is electromagnetic waves sent through the air. An example of this type of transmission is (**television, telegraph**) signals.

5. Match devices for control of electrical power on the right with the correct descriptions.

______a. Solid state devices used for switching and/or amplifying the flow of electrons in a circuit

______b. Used to control a circuit from a remote location

______c. Most common electrical control device

______d. Reduce current flow and control voltage drop

______e. Have the same job as a fuse, but can be reset by hand after circuit is broken

______f. Permit current to flow in only one direction; solid state

______g. Allow current to be stepped up or down

______h. Protect a circuit from dangerous overloads; must be replaced after use

1. Circuit breakers
2. Diodes
3. Fuses
4. Manual switch
5. Relays
6. Resistors
7. Transformers
8. Transistors

TEST

6. Select true statements concerning the principles of hydraulics by placing a "T" or "F" in the appropriate blank.

_____a. Liquid can be compressed like a gas.

_____b. Pressure set up in a confined liquid acts equally in all directions.

_____c. If the input and output pistons have equal areas and equal pressures, the output force will be equal to the input force.

7. Match the parts of a hydraulic system on the right with the correct functions.

_____a. Drives the pump

_____b. Supplies fluid under pressure to system

_____c. Stores the fluid

_____d. Cleans the fluid

_____e. Opens to relieve excess pressure and to prevent damage to both the system and the surroundings

_____f. Regulates fluid pressure, flow rate, and direction of flow

_____g. Transfers fluid pressure in system to piston which pushes load; changes fluid pressure into mechanical motion

1. Control valve
2. Cylinder
3. Filter
4. Motor, turbine, or engine
5. Pressure relief valve
6. Pump
7. Reservoir or tank

8. Arrange in order the steps in the operation of hydraulics by placing numbers 1-4 in the correct sequence.

_____a. Hydraulic pressure causes the piston to move and perform work.

_____b. Oil pump draws the oil from the reservoir.

_____c. Oil is directed to double-acting cylinders.

_____d. Oil passes to the chambers of a control valve.

9. List two applications of hydraulic transmissions in each of the following areas.

a. Automotive — ________________________________

b. Manufacturing — ________________________________

c. Aerospace — ________________________________

d. Agriculture — ________________________________

e. Construction — ________________________________

TEST

10. Select advantages of a hydraulic system by placing an "A" in front of the appropriate statements.

_____a. Liquids are not subject to wear or breakage.

_____b. Require no lubrication

_____c. Transmitted motion is smooth and consistent.

_____d. Restricted to certain areas/conditions.

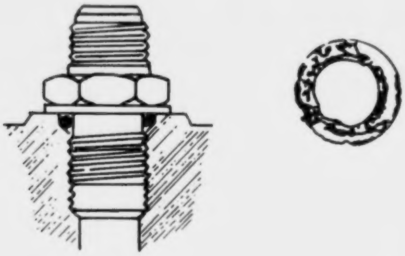
_____e. Are simple having no gears or levers

_____f. Closed or sealed system prevents entry of dirt and resulting wear.

_____g. Require much lubrication

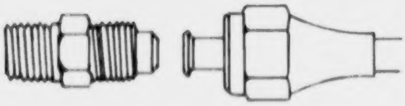
11. Identify connectors used in fluid power systems by placing the appropriate number in the blank.

_____a.

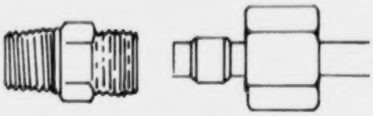


1. Compression sleeve fitting
2. Fitting with O-ring seal
3. Flared tube fitting
4. Quick-disconnect fitting with barbed fasteners

_____b.

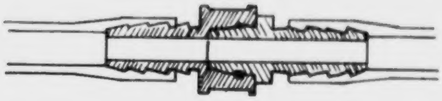


_____c.



TEST

_____d.



12. Distinguish between the two laws defining the principles of pneumatics by placing a "B" in front of Boyle's law and a "C" in front of Charles' law.

_____a. If the volume of air or gas in a cylinder is compressed to one-half of its original volume, its pressure will double.

_____b. When the volume of a gas remains constant and its temperature increases, the pressure increases proportionally.

13. Match parts of a pneumatic system on the right with the correct functions.

_____a. Drives the air compressor
_____b. Increases the pressure of the air or gas
_____c. Opens to relieve excess pressure
_____d. Removes dirt from the air
_____e. Monitors and controls the desired air pressure in the line
_____f. Adds some oil to the air passing through and reduces friction between sliding surfaces
_____g. Regulates flow rate and direction of air
_____h. Converts pressure into mechanical motion

1. Air compressor
2. Control valve
3. Cylinder or other actuator
4. Filter
5. Lubricator
6. Motor or engine
7. Pressure relief valve
8. Regulator

14. List four applications of pneumatics.

a. ____

b. ____

c. ____

d. ____

TEST

15. Match terms related to robotics listed on the right with the correct definitions.

______a. The working area of the robot

______b. Supplies hydraulic, pneumatic, or electric power to move the manipulator

______c. A handlike, pinching device that holds the part being moved or worked on or the tools doing the work

______d. The number of rotary center points on which motion is performed; may have 1-6 of these

______e. Part of the robot that is programmed to move and to pick up and place parts or hold tools for work procedures

______f. Part of the robot that directs the motion of the robot's manipulator

1. Axes
2. Controller
3. Envelope
4. Gripper
5. Manipulator
6. Power supply

16. Distinguish between the two major categories of jobs in industry well suited for robots by placing an "X" next to the description of repetitive jobs and an "O" next to the hazardous jobs.

______a. Tasks that must be performed hundreds of times each day

______b. Tasks that are dangerous or harmful to humans because of toxic fumes, high levels of radiation, etc.

17. Complete statements concerning the principles of lasers by circling the appropriate words.

a. Laser beams consist of (**telegraphic, electromagnetic**) waves at or near the wavelength of visible light.

b. The waves in a laser have almost identical lengths enabling it to travel in a straight line for miles with (**a great deal of, very little**) spreading.

c. Laser wavelengths are very (**short, long**).

TEST

18. Match classes of lasers on the right with the correct descriptions.

_____a. Are a potential hazard to the eye and to exposed skin; can produce enough light energy to burn any combustible material

_____b. Produce low powered light; cannot cause damage to anyone or anything

_____c. Can damage the eye only if the eye is deliberately exposed to the beam for periods of time longer than the normal blinking of the eye

_____d. Can produce light of high enough intensity to injure a human eye before the eye can blink

1. Class I
2. Class II
3. Class III
4. Class IV

19. List four applications of lasers.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

20. Match types of energy on the right with the correct examples of storage devices.

_____a. Springs and flywheels

_____b. Capacitors and inductors

_____c. Fossil fuels

_____d. Air tanks and accumulators

1. Fluid energy
2. Electrical energy
3. Mechanical energy
4. Chemical energy

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

21. Determine gear rotation. (Assignment Sheet #1)

22. Design and build a robotic arm. (Assignment Sheet #2)

23. Demonstrate the ability to:

  a. Build a "big track" robot. (Job Sheet #1)

  b. Build a lemon battery. (Job Sheet #2)

POWER TRANSMISSION AND STORAGE
UNIT IV

ANSWERS TO TEST

1. a. 8
   b. 9
   c. 1
   d. 6
   e. 2
   f. 7
   g. 3
   h. 4

2. a. M
   b. F
   c. E

3. a. 11
   b. 2
   c. 7
   d. 6
   e. 4
   f. 10
   g. 8
   h. 1
   i. 3
   j. 5
   k. 9

4. a. High
   b. Television

5. a. 8
   b. 5
   c. 4
   d. 6
   e. 1
   f. 2
   g. 7
   h. 3

6. a. F
   b. T
   c. T

7. a. 4
   b. 6
   c. 7
   d. 3
   e. 5
   f. 1
   g. 2

8. a. 4
   b. 1
   c. 3
   d. 2

9. Two applications for each of the following:
   a. Automotive — Power brakes, power windows, automatic transmissions, power steering, shock absorbers
   b. Manufacturing — Machine tools, food and chemical processors, plastics, presses, loaders
   c. Aerospace — Aircraft, landing gears, helicopters, satellites

ANSWERS TO TEST

- d. Agriculture — Automatic bale loaders, machinery hoists, tractors, grain beds, pickers, threshers
- e. Construction — Road graders, shovels, rock crushers, bulldozers

10. a, b, c, e, f

11. a. 2
    b. 3
    c. 1
    d. 4

12. a. B
    b. C

13. a. 6
    b. 1
    c. 7
    d. 4
    e. 8
    f. 5
    g. 2
    h. 3

14. Any four of the following:
    a. Aerosol-powered liquids — Spray paint
    b. Die casting — Forcing molten metal into molds
    c. Forging — Shaping hard-to-work metal
    d. Aerospace — Engine control units to correct yaw and pitch
    e. Transportation — Tires and brake systems
    f. Pneumatic tools — Air drills, staplers, riveting guns

15. a. 3
    b. 6
    c. 4
    d. 1
    e. 5
    f. 2

16. a. X
    b. O

17. a. Electromagnetic
    b. Very little
    c. Short

18. a. 4
    b. 1
    c. 2
    d. 3

ANSWERS TO TEST

19. Any four of the following:
    a. In communications, lasers are used with fiberoptics to transmit telephone conversations.
    b. In industry, lasers are used to drill holes and braze or weld metals.
    c. In medicine, lasers are used to cut tissue and then seal tissues together so stitches are not needed.
    d. In construction, lasers are used with surveying equipment for more accurate measurements of distances and elevations.
    e. In consumer products, lasers are used to scan items in supermarket checkouts and video disks readers.

20. a. 3
    b. 2
    c. 4
    d. 1

21.-22. Evaluated to the satisfaction of the instructor

23. Performance skills evaluated to the satisfaction of the instructor

TRANSPORTATION SYSTEMS
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between the modes of transportation, select appropriate modes of transportation for given situations, and set up and operate a pipeline simulation. Competencies will be demonstrated by completing the assignment sheet, job sheet, and unit tests with a minimum of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to transportation systems with the correct definitions.
2. List the four basic modes of transportation.
3. Match types of intermodal transportation with their uses.
4. Complete statements concerning the types of on-site transportation.
5. Complete statements concerning highway transportation.
6. Complete statements concerning rail transportation.
7. Identify types of railway vehicles.
8. Match types of commercial airlines with the correct descriptions.
9. Distinguish between the basic types of airplanes.
10. Identify parts of an airplane.
11. Complete statements concerning space transportation.

OBJECTIVE SHEET

12. Match U.S. space projects with their contributions.
13. Complete statements concerning characteristics of the space shuttle.
14. Match basic vessels for water transportation with the correct descriptions.
15. Identify the basic parts of a ship.
16. List uses of computers for transportation systems.
17. Select modes of transportation for given situations. (Assignment Sheet #1)
18. Demonstrate the ability to set up and operate a pipeline simulation. (Job Sheet #1)

TRANSPORTATION SYSTEMS
UNIT V

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included with this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

(NOTE: Use the transparency to enhance the information as needed.)

G. Provide students with job sheet.

H. Discuss and demonstrate the procedure outlined in the job sheet.

I. Integrate the following activities throughout the teaching of this unit:

1. Show films on transportation. Suggested films are listed on the next page.
2. Invite a travel agent to present a discussion on air travel. Include cost, schedules, service, and airlines companies in the presentation.
3. Invite a representative from a local pipeline or utility company to discuss the operation of a pipeline system. Include planning, organization, and controlling the product as they travel through the lines.
4. Discuss the advantages and disadvantages of each mode of transportation. Consider economics, speed, and environmental factors.
5. Discuss the different kinds of city, state, and federal government vehicles that are used in your community.
6. Using local telephone books, have students locate and list the different small package express companies that serve your area.
7. Trace a consumable food product through the different types of transportation involved in getting that product from the fields to the table.

SUGGESTED ACTIVITIES

8. Discuss how products such as televisions, refrigerators, stoves, hair dryers, radios, and other household goods get from the manufacturers to retail stores to consumers.

9. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Berghauser, Thomas and Michael Kozak. *Systems of Technology: Laboratory Activities in Energy.* Austin, Texas: EIMC, 1986.

B. Hughes, Larry R. *Energy Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

C. Hughes, Larry R. and Alan L. Towler. *Transportation Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

D. Johnson, Jim. *Laser Technology: An Individual Learning Course.* Benton Harbor, Michigan: Heath Company, 1985.

E. *Principles of Technology: Energy.* Waco, Texas: Center for Occupational Research and Development, 1985.

F. Towler, Alan L. *Power Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

SUGGESTED SUPPLEMENTAL RESOURCES

Films:

A. *Ballad of the Iron Horse;* 1970 #08355; color; 30 min

B. *Quest for Flight,* 1976; #01976; color; 23 min

(NOTE: A and B are available from:
Bureau of Audiovisual Instruction
P.O. Box 2093
Madison, Wisconsin 53701-2093
608-262-1644)

C. *Blue Sky Below My Feet — Adventures in Space Technology*
National 4-H Council
7100 Connecticut Ave.
Chevy Chase, MD 20915
301-961-2860

SUGGESTED SUPPLEMENTAL RESOURCES

D. *The Transportation Revolution: Story of America's Growth;* #03547; 19 minutes; color
OSU AudioVisual Center
Stillwater, Oklahoma 74078
(405) 624-7216

E. *American Transportation: Horseback to Jet* (#266)
Life Filmstrips
Time-Life Building
Rockefeller Center
New York, NY 10020

Pamphlets and Charts

A. *List of FAA Aviation Education Material* and *The Main Parts of an Airplane*
Department of Transportation
Federal Aviation Administration
Washington, DC 20591

B. *America Runs on Wheels* and *Trucks and Buses Serve America* (wall chart)
Motor Vehicle Manufacturer's Association of the U.S., Inc.
300 New Center Building
Detroit, Michigan 48202

C. *Who in the World Needs Railroads?*
Public Relations Department
Atchison, Topeka, and Santa Fe Railway
80 E. Jackson Boulevard
Chicago, IL 60604

D. *Plane Folder* (pictures of planes)
Delta Airlines, Inc.
Public Relations Department
Hartsfield-Atlanta International Airport
Atlanta, GA 30320

E. *Airports and Jets*
Department of Airports
Public Relations
Los Angeles International Airport
1 World Way
Los Angeles, CA 90009

F. *Big Load Afloat*
The American Waterways Operators, Inc.
1600 Wilson Boulevard
Suite 1101
Arlington, VA 22209

SUGGESTED ACTIVITIES

G. *United States Road Symbol Signs*
U.S. Department of Transportation
Federal Highway Administration
Office of Public Affairs (HPA-1)
400 Seventh Street, S.W.
Washington, DC 20590

NATIONAL AGENCIES OFFERING OTHER EDUCATIONAL RESOURCES

A. Department of Transportation
400 Seventh Street SW
Washington, D.C. 20590

B. Department of Energy
1000 Independence Avenue SW
Washington, D.C. 20585

C. Environmental Protection Agency
401 M Street SW
Washington, D.C. 20460

D. National Aeronautics and Space Administration
400 Maryland Avenue SW
Washington, D.C. 20546

TRANSPORTATION SYSTEMS
UNIT V

INFORMATION SHEET

I. **Terms and definitions**

   A. Cargo/freight — Solid, liquid, or gaseous material being moved from one place to another

   B. Intercity — Between cities

   C. Intermodal transportation — Moving passengers or cargo using more than one mode or method

   D. Interstate — Between states

   E. Intracity — Within the city

   F. Intrastate — Within the state

   G. On-site transportation — Moving people and/or materials over short distances within one particular area or building

   H. Passengers — People who are being transported from place to place

   I. Terminals — The beginning and ending points for loading and unloading passengers and cargo

   J. Transportation — The movement of people and material

   K. Vehicles — Transportation devices

      Examples: Buses, cars, trucks, airplanes, railroad cars

II. **Basic modes of transportation** (Transparency 1)

   A. Land

   B. Water

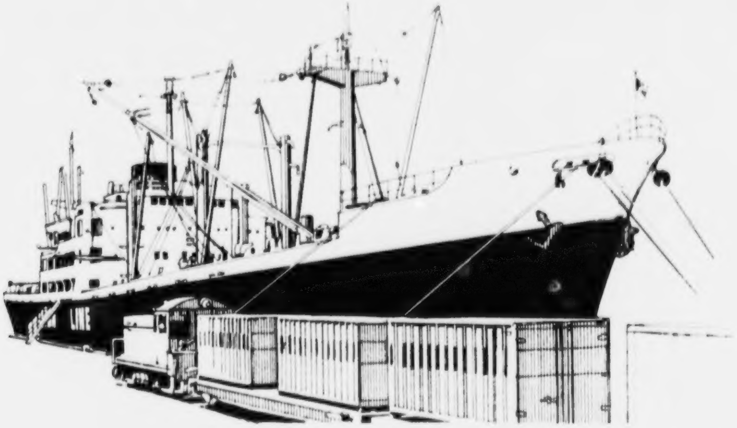
   C. Air

   D. Space

INFORMATION SHEET

III. **Types of intermodal transportation**

A. Containerization — Shipping goods in large boxes which can be filled at one location, transported via different modes, and delivered to its destination without rehandling the goods



B. Freight forwarders — The middle persons in transportation who collect small loads from shippers, consolidate them into a large load, and forward the large load to the next receiver

Examples: Mistletoe, Beaver Express

C. Small package express service — The delivery of packages or parcels in the fastest and most direct way possible

Examples: U.P.S., Federal Express, Air Express

IV. **Types of on-site transportation** (Transparency 2)

A. Materials handling — Movement of raw and finished products inside the building using conveyors, cranes and hoists, industrial trucks, and fork lifts

B. People moving — Movement of individuals inside the building using escalators, elevators, and moving sidewalks

V. **Highway transportation** (Transparency 3)

A. Highways are used to move people and materials.

1. Moving people

a. Personal transportation — Automobiles and trucks are used to move people to and from their work places and for recreation activities.

(NOTE: People may also use specialized vehicles such as recreational vehicles [RVs] for their own use.)

INFORMATION SHEET

b. Commercial and government transportation — Buses and taxis are primarily used to move people intracity, intercity, and interstate for commercial profit or public service.

2. Moving materials

a. Personal transportation — Automobiles and trucks may be used to move materials for an individual's own use.

Examples: Groceries, household purchases

b. Commercial transportation — Trucks, vans, and tractor-trailer combinations are primarily used to haul materials for profit.

Examples: Refrigerated trailers are used to transport food items that may spoil, vans are used by appliance repair firms, tankers are used to transport liquid freight

B. Highways form an elaborate network of local, state, and interstate highways which connect all locations of the nation.

(NOTE: These interconnections make highway transportation a very flexible form of transportation. If you have a vehicle and a license to operate that vehicle, you can travel in the United States when and where you wish.)

VI. Rail transportation

A. Primarily used for commercial transportation of passengers and freight over long distances.

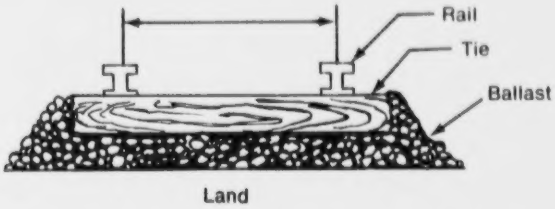
1. Examples of commercial passenger lines — Amtrak and rapid transit trains

2. Examples of commercial freight lines — B & O, Santa Fe, and Union Pacific

INFORMATION SHEET

B. Railway systems consist of the railways and the buildings and areas used to classify, schedule, and maintain vehicles.

1. A railway has four parts — Right-of-way land, ballast, ties (or crossties) and rails

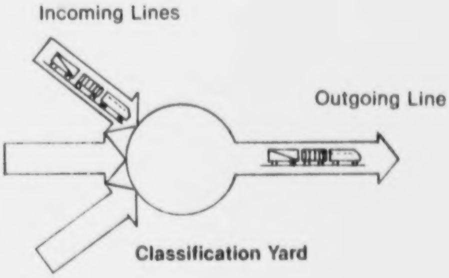


(NOTE: All railroad tracks in North America are built to a standard gauge [width apart] of 4′8½″ so rails can be shared by all companies.)

2. Stations — For loading and unloading passengers

3. Freight terminals — For loading and unloading freight

4. Classification yards — Complexes of tracks for joining railroad cars or for breaking up and regrouping cars to make more efficient use of the railways



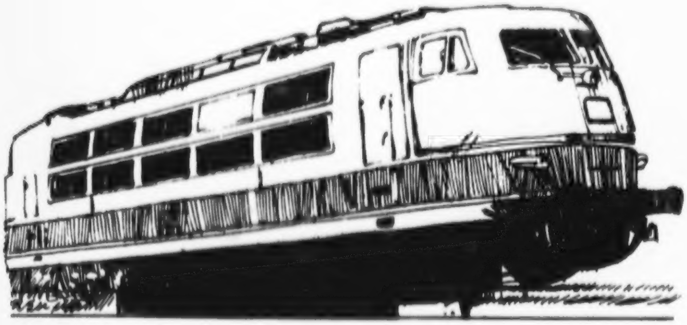
5. Control center — For monitoring the switching of trains and cars by dispatchers

6. Engine/car shops — For major repairs and maintenance work

INFORMATION SHEET

VII. Types of railway vehicles

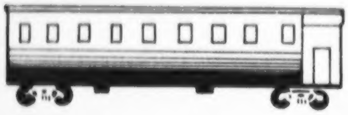
A. Locomotives — Power the train



1. Most locomotive engines today are diesel-electric which use diesel fuel to power generators that supply electricity to traction motors that drive the wheels.

2. Other types include steam engines, gas turbine engines, and all electric engines.

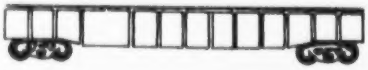
B. Passenger cars — Carry passengers



C. Freight cars — Carry various types of freight

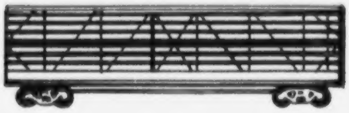
1. Standard flat car

2. Standard gondola car

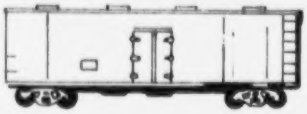


INFORMATION SHEET

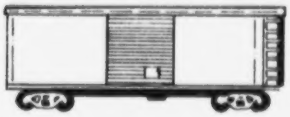
3. Single deck livestock car



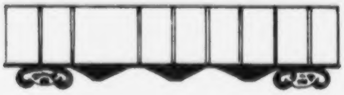
4. Standard refrigerator car



5. Box car



6. Hopper — open



VIII. **Types of commercial airlines**

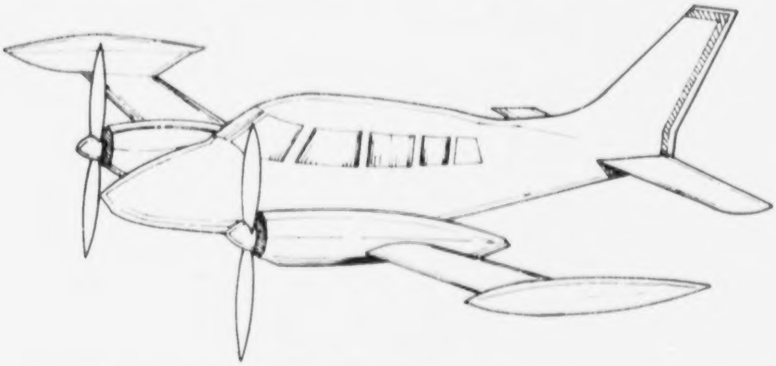
A. Nonscheduled — Charter planes

B. Scheduled

1. International — Fly between U.S. and other countries
2. Domestic — Fly to and from major airports of the U.S.
3. Regional — Fly only specific regions of the U.S.
4. Commuter — Fly from smaller towns and cities to major airports in the U.S.

IX. **Types of airplanes**

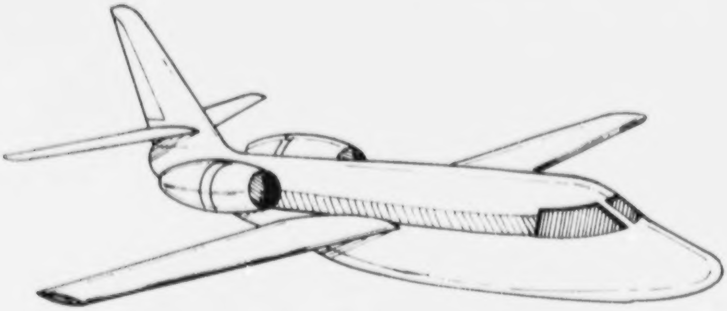
A. Prop planes — Powered by an engine-driven propeller



(NOTE: Propeller engines are very efficient at speeds below 560 kph [350 mph]. As speed increases above that, efficiency drops off.)

INFORMATION SHEET

B. Jet planes — Powered by jet engines



(NOTE: Jet engines are more efficient at high speeds.)

X. **Parts of an airplane** (Transparency 4)

A. Fuselage — Body of the airplane; holds the passengers and/or cargo

B. Engine (piston or jet) — Powers the airplane

C. Wing assembly — Provides lift to keep airplane airborne

1. Wings
2. Flaps
3. Ailerons

D. Tail assembly (empennage) — Controls direction of airplane

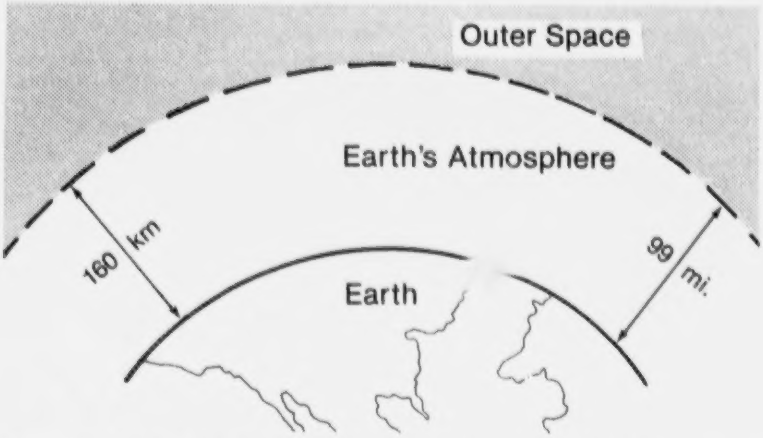
1. Vertical stabilizer
2. Rudder
3. Horizontal stabilizer
4. Elevator

E. Landing gear — Allows for physical contact with the ground

INFORMATION SHEET

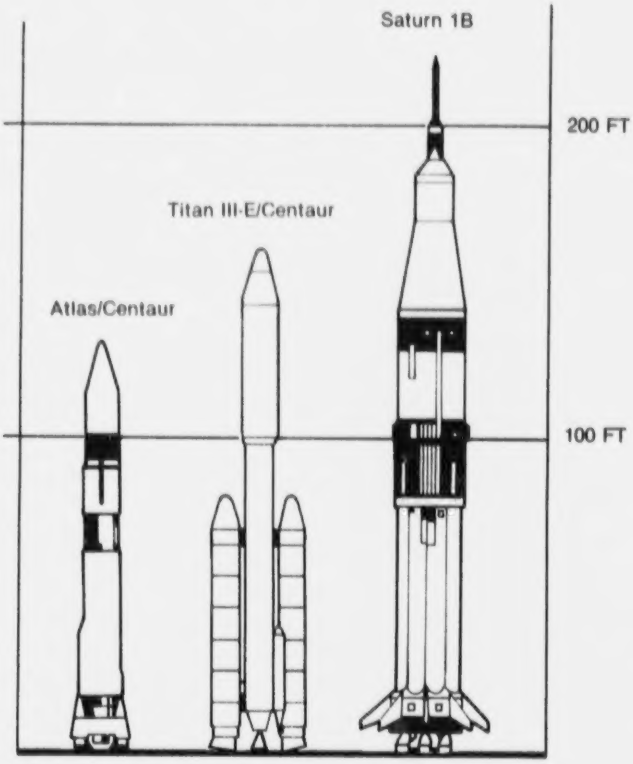
XI. Space transportation

A. Is an exploration of the region outside the earth's atmosphere


Outer Space
Earth's Atmosphere
160 km
99 mi.
Earth

B. Use rocket engines which carry their own fuel and oxygen supplies.

C. Use large launch vehicles to place spacecraft into orbit.

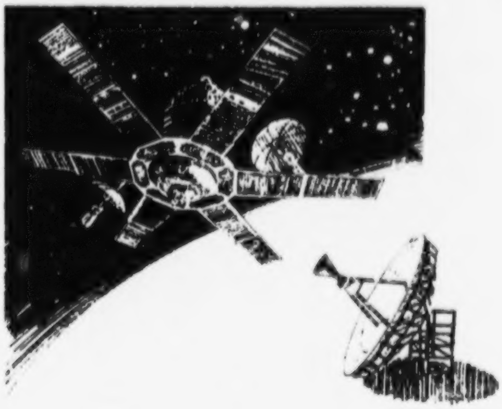

Saturn 1B
200 FT
Titan III-E/Centaur
Atlas/Centaur
100 FT

INFORMATION SHEET

D. Spacecraft are classified as manned or unmanned.

1. The first man-made satellite was put into orbit on October 4, 1957 by the U.S.S.R. It was called Sputnik.

2. Unmanned space vehicles are used for communication, weather forecasting, and military reconnaissance.



3. The first person in space was Russian cosmonaut Yuri Gagarin on April 12, 1961. He orbited the earth one time.

4. The United States followed closely after this with manned flights by American astronauts Alan Shepard, Virgil Grissom, and John Glenn.

XII. **U.S. space projects (1961-present)** (Transparency 5)

A. Mercury (1961-63) — Put first American in space; had six, one-manned flights

B. Gemini (1965-66) — Orbited astronauts around the earth; accomplished docking and rendevous procedures; had ten, two-manned flights

C. Apollo (1967-1972) — Put first Americans on the moon (1969); had eleven three-manned flights; conducted lunar (moon) walks and experiments

D. Skylab (1973-1979) — Made transition from space exploration to space utilization; was a space station for experiments that stayed in orbit for more than 6 years; 4 manned missions were made to Skylab.

E. Space shuttle (1976-Present) — Developed a space vehicle that could be reused

INFORMATION SHEET

XIII. **Characteristics of the space shuttle**

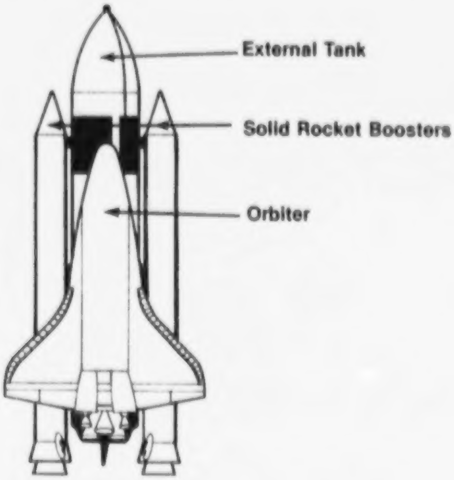
A. There are four major elements in the shuttle system.

1. The orbiter (shuttle) — Reusable aircraft resembling a jetliner

   Examples: *Enterprise, Columbia, Challenger*

2. External tank — Holds the liquid propellants for main engines

3. Two solid rocket boosters — Recoverable and reusable



B. Shuttle is launched vertically as its own liquid fuel rocket engines fire with the solid rocket boosters.

(NOTE: The boosters are dropped off and recovered for reuse.)

C. The shuttle can carry up to seven people into orbit and up to 65,000 lbs. of cargo such as satellites, replacement parts, and other equipment. It also has a manipulator arm that serves many functions, including retrieving satellites in need of repair.

D. The shuttle reenters the atmosphere and descends as a glider.

XIV. **Basic vessels used for water transportation**

A. Boats — Smaller watercraft propelled by oars, sails, or engines for recreational or commercial use

Examples: Ski boats, fishing boats, tugboats

INFORMATION SHEET

B. Ships — Larger watercraft propelled by engines for commercial transportation of people or cargo

Examples: Luxury ocean liners, freighters

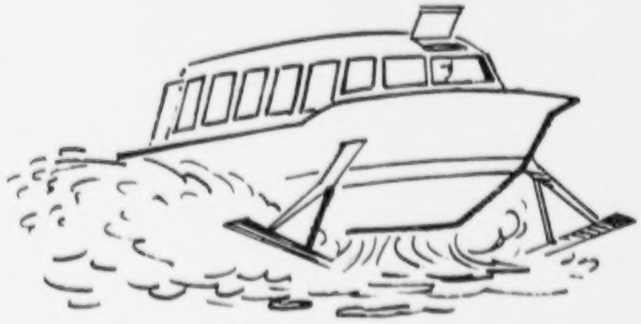
C. Barges — Flat, commercial cargo vessels that are pushed or pulled by engine-driven vessels (tugboats or towboats)

D. Military vessels — Vessels used by U.S. armed forces (especially the Navy) for defense and service of the country

Examples: Aircraft carriers, patrol boats, submarines, battleships

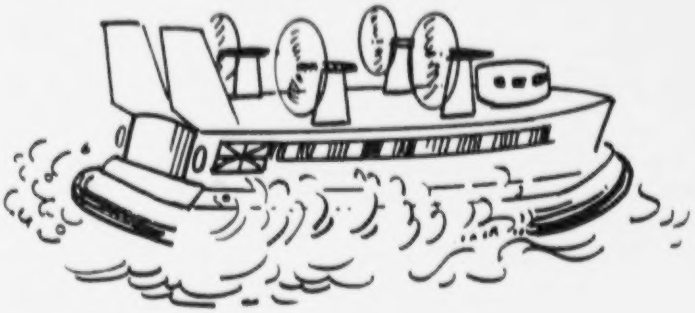
E. Specialized craft — Hydrofoils and hovercrafts

1. Hydrofoils — Crafts supported on wings (foils) that create lift for the boat by deflecting water over their surfaces



Hydrofoil

2. Hovercrafts — Vehicles that rely on a cushion of air between the hull or body and the surfaces over which it operates; can travel over land or water



Hovercraft

INFORMATION SHEET

XV. **Basic parts of a ship** (Transparency 6)

- A. Hull — Shell or plating
- B. Keel — Lowermost part running the length of the ship
- C. Bow — Forward end
- D. Stern — Back section
- E. Bridge — Control room
- F. Decks — Layers or levels; main deck is uppermost

XVI. **Uses of computers in transportation systems**

- A. Highway transportation
    1. Vehicle production and assembly
    2. Computerized ignition systems
    3. Computerized diagnostic and test equipment
    4. Computer controlled traffic flow
    5. Law enforcement
    6. Trucking company recordkeeping
- B. Rail transportation
    1. Customer billing
    2. Reservations on passengers trains
    3. Switching operations
    4. Car identification
- C. Air transportation
    1. Airplane design
    2. Air traffic control
    3. Airplane gauges and controls
    4. Airline reservations

INFORMATION SHEET

D. Space transportation

   1. Tracking space vehicles

   2. On-board navigation guidance systems

   3. On-board communication systems

   4. Life support monitoring

   5. Launching operations

   (NOTE: Space travel would be impossible without computers.)

E. Water transportation

   1. Navigation

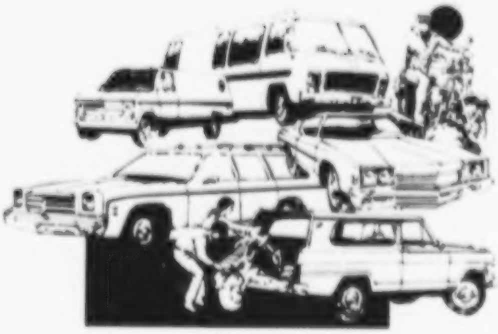
   2. Scheduling passengers or cargo

F. Stationary transportation

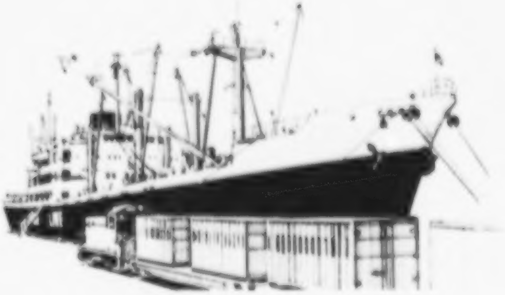
   1. Controlling speed and distribution of products for pipelines and conveyors

   2. Monitoring load requirements in elevators and escalators

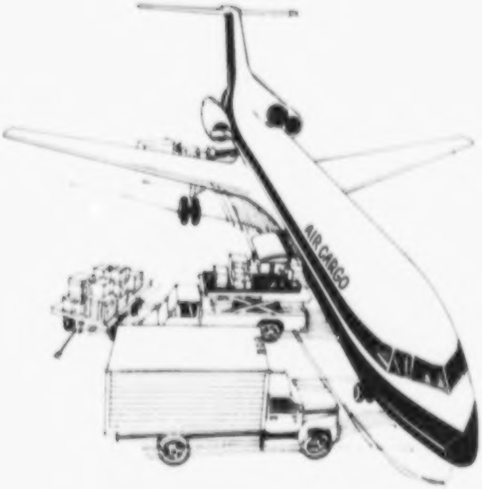
Basic Modes of Transportation



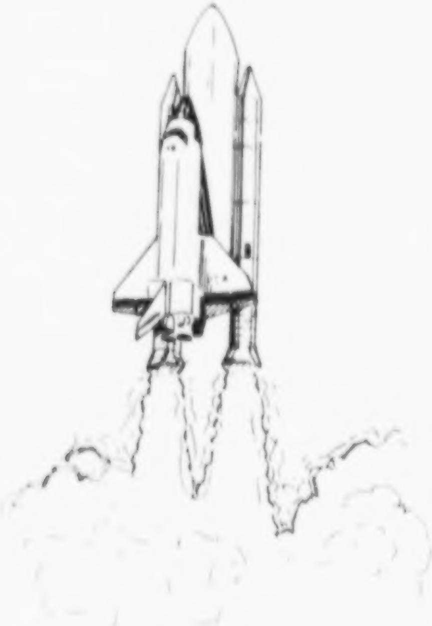
Land



Water



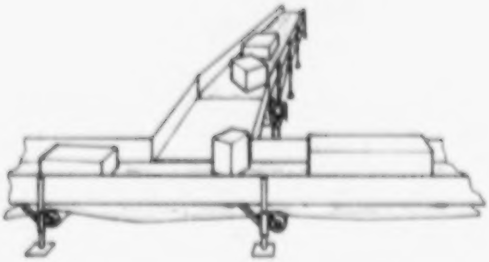
Air



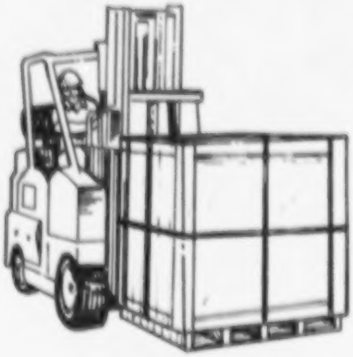
Space

TM 1

Types of On-Site Transportation

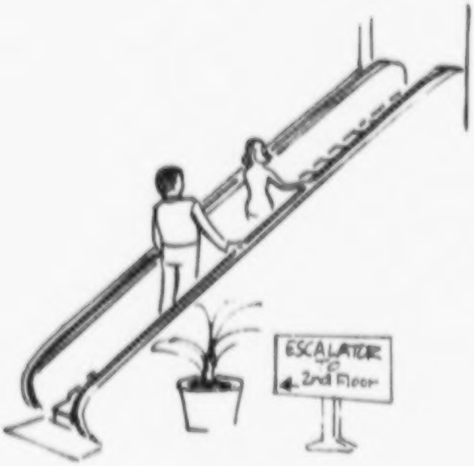


Conveyor

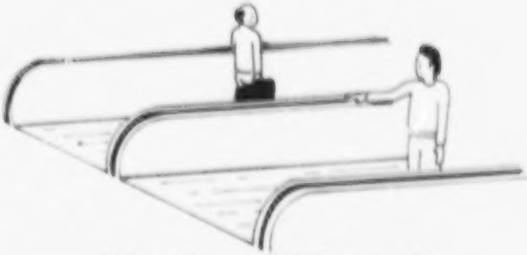


Fork Lift

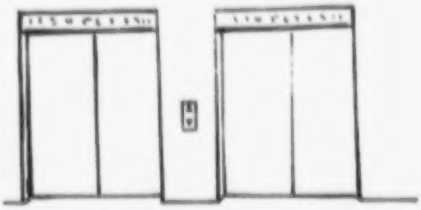
Materials Handling


ESCALATOR
to
2nd Floor

Escalator



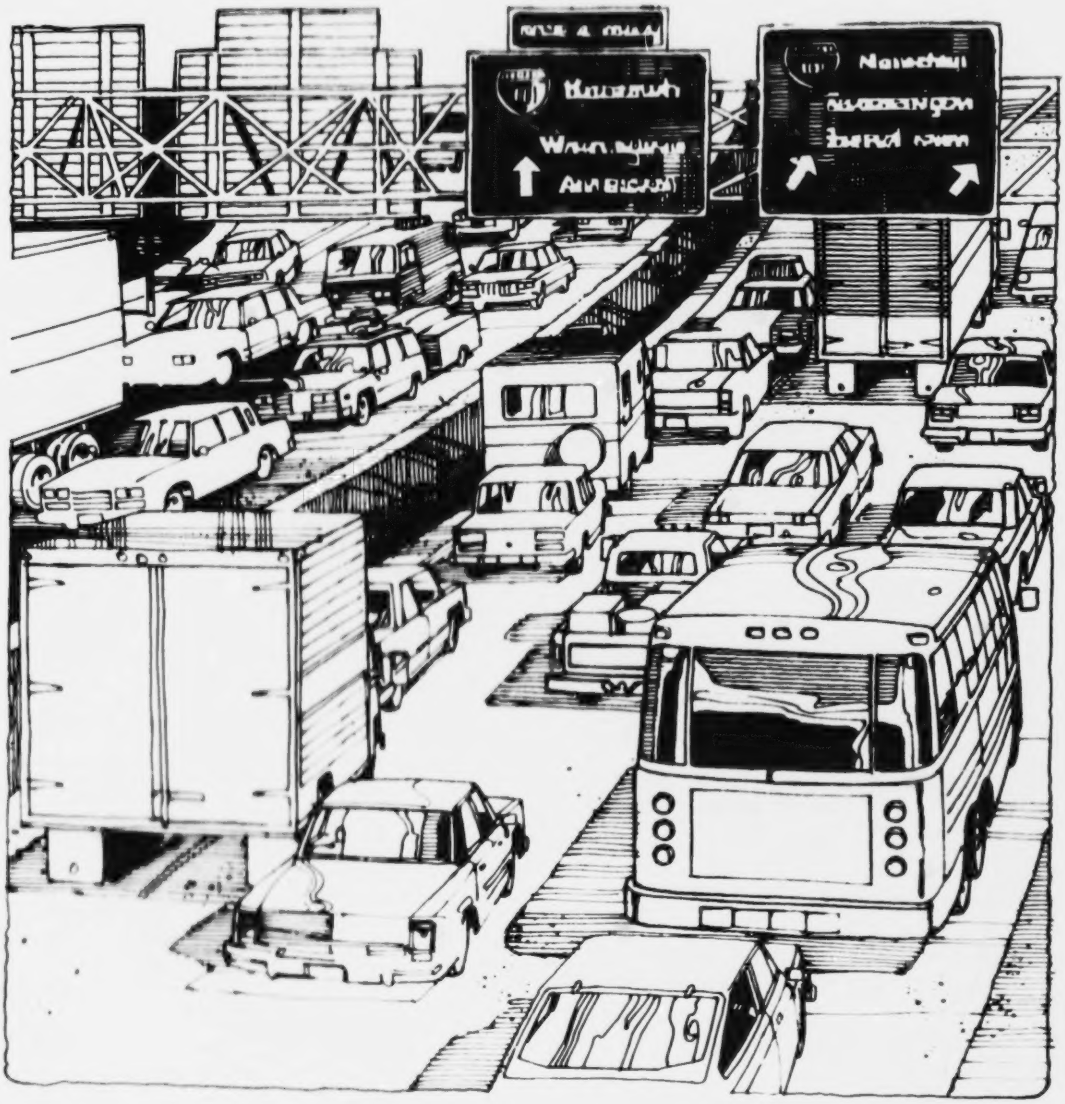
Moving Sidewalk



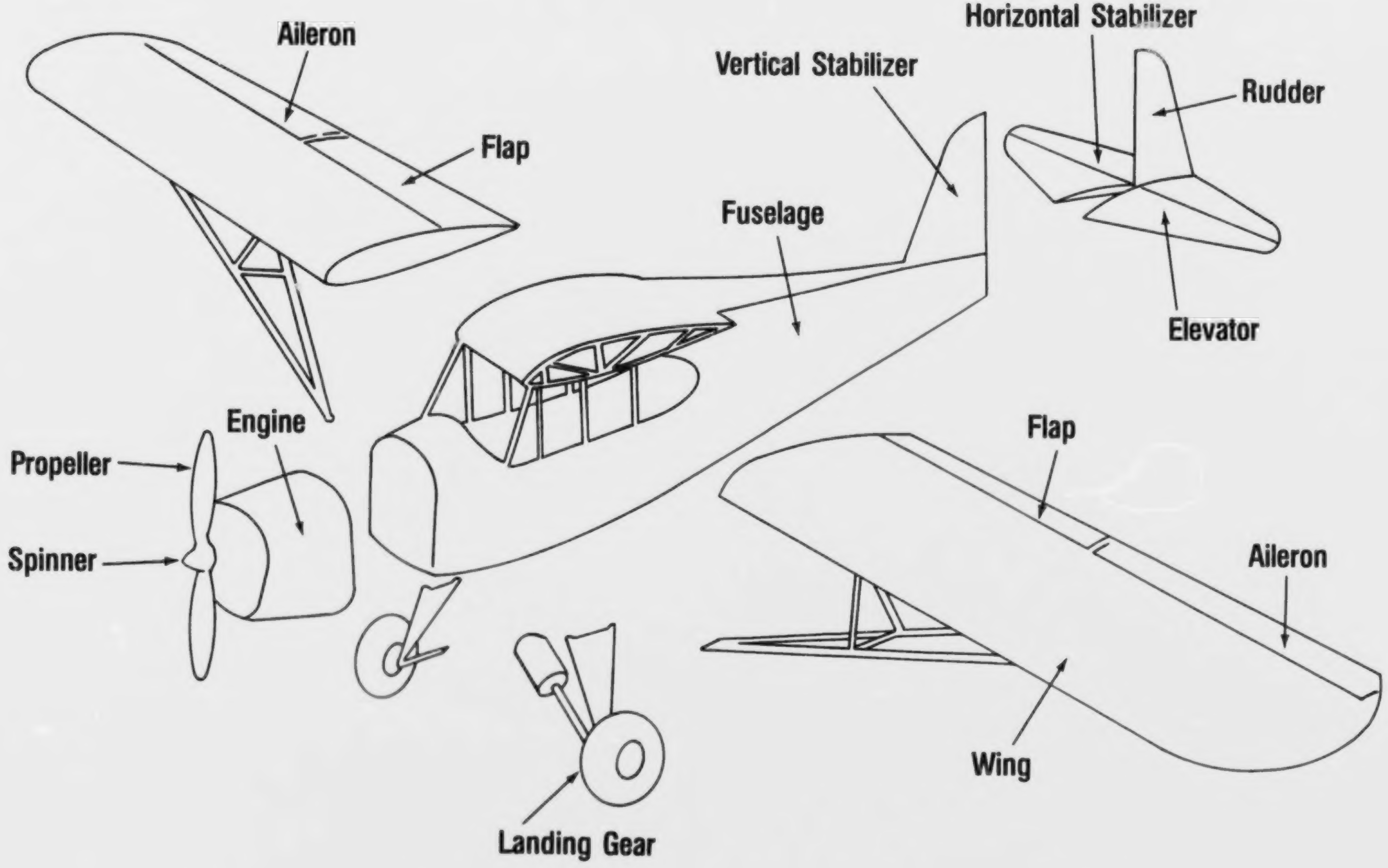
Elevator

People Moving

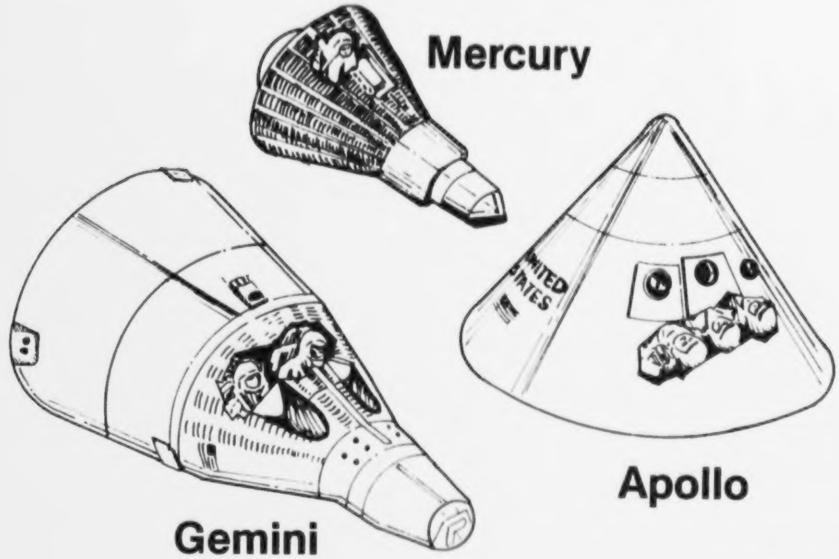
Highway Transportation

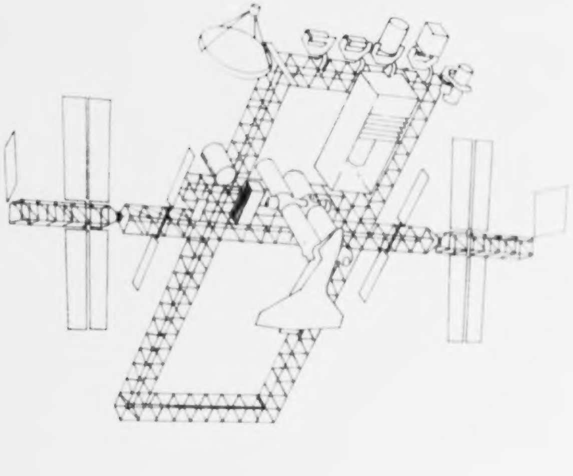


Parts of an Airplane

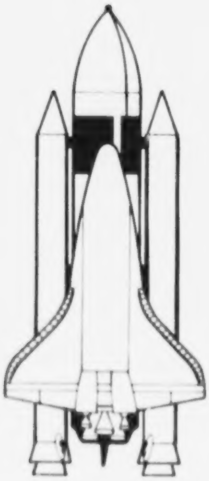

Aileron
Flap
Vertical Stabilizer
Horizontal Stabilizer
Rudder
Fuselage
Elevator
Engine
Propeller
Spinner
Flap
Aileron
Wing
Landing Gear

U.S. Space Projects


Mercury
UNITED STATES
Apollo
Gemini

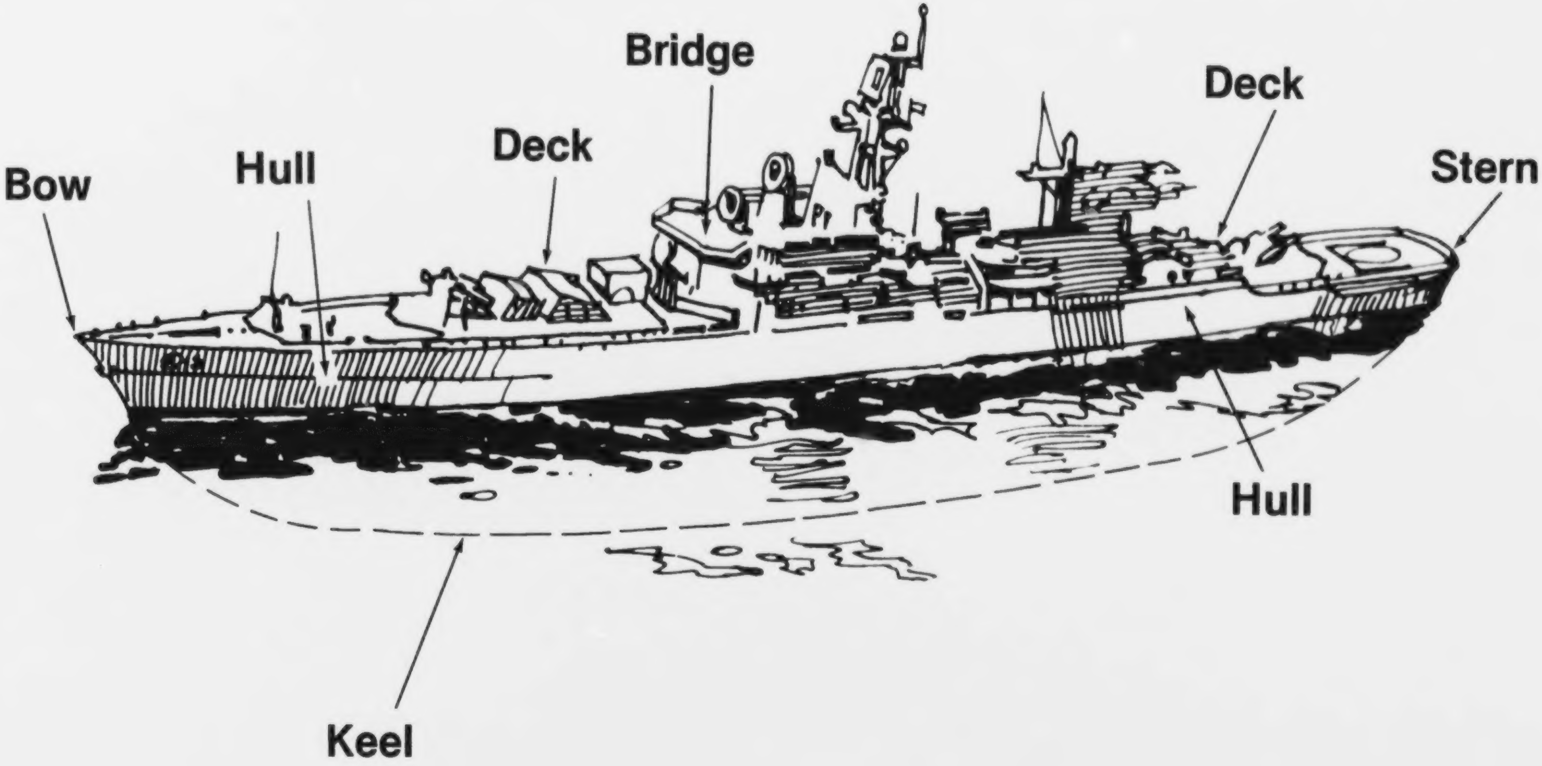


Skylab



Space Shuttle

Basic Parts of a Ship


Bridge
Deck
Bow
Hull
Deck
Stern
Hull
Keel

TRANSPORTATION SYSTEMS
UNIT V

ASSIGNMENT SHEET #1 — SELECT MODES OF TRANSPORTATION FOR GIVEN SITUATIONS

NAME ______________________________ SCORE ____________

A. Directions: There are many factors to consider when choosing the mode of transportation you will use to carry cargo. You will examine several of these factors, then make a decision regarding which mode to use in a given situation.

B. Problem: Assume that you have a one-and-one-half ton load of break bulk cargo that you need to move from New Orleans, Louisiana to New York City, New York. You may choose between four modes of commercial transportation. You call four different companies. They each quote you a price for their services and tell you how much time it will take. The shipping costs and times for each company are:

Speedy Shipping — $78 per ton, 7 days
Rapid Railroad — $156 per ton, 3½ days
Fast Trucking — $247 per ton, 35 hours
Lightning Air Cargo — $2500 per ton, 2½ hours

C. Procedure:

1. Calculate the cost for each mode. Write your answers in the proper spaces on Figure 1.

FIGURE 1

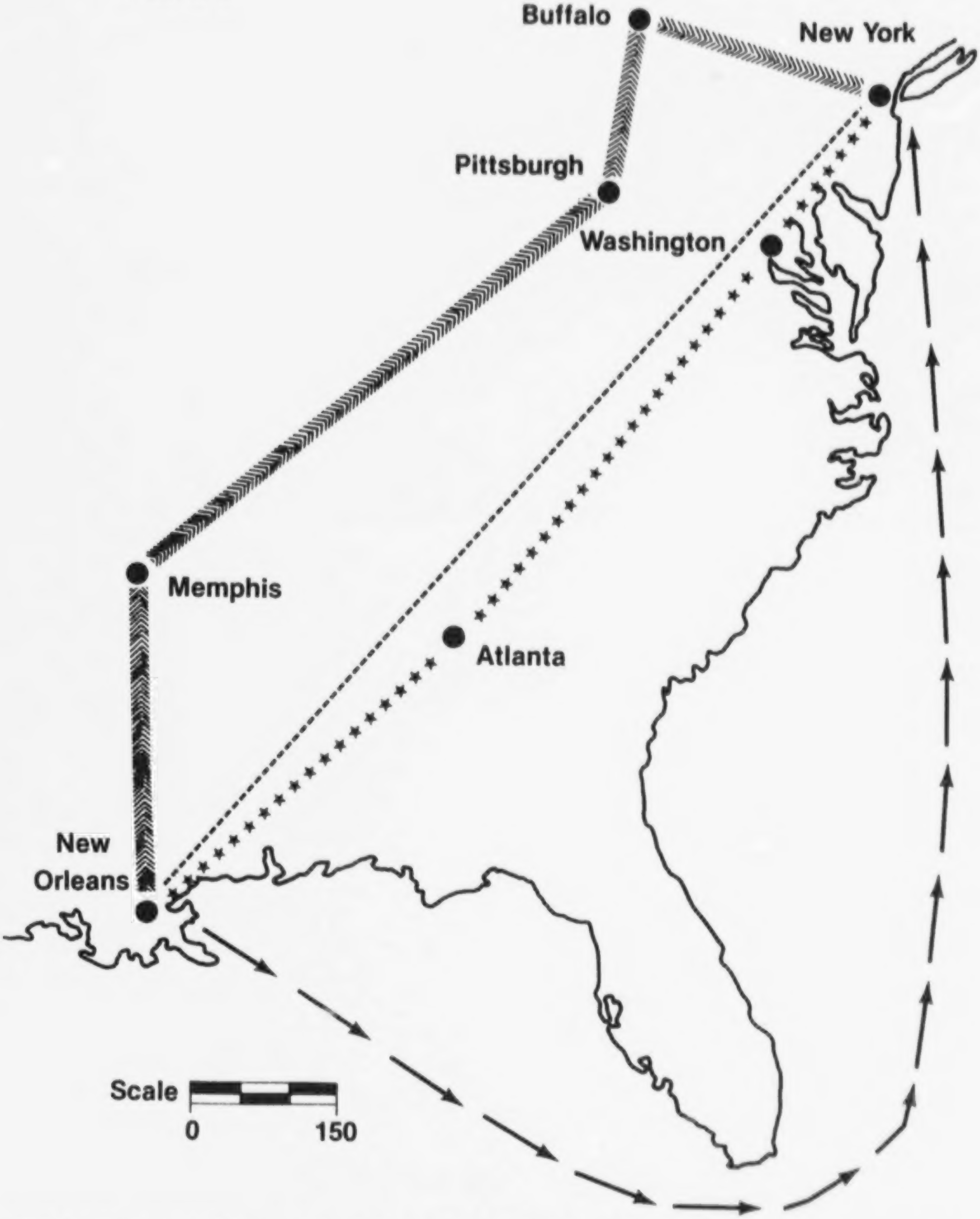
Mode	Route	Company	Cost	Time	Distance	Average Speed
Ship	⟶	Speedy Shipping				
Rail	»»»»»»»»	Rapid Railroad				
Truck	* * * *	Fast Trucking				
Air	-------	Lightning Air Cargo				

2. Calculate the time in hours for each mode. Write your answers on the same chart.

3. Measure each carrier's route and determine the distance in miles, using a ruler and the map, Figure 2. Write your answers on the chart.

ASSIGNMENT SHEET #1

FIGURE 2


Buffalo
New York
Pittsburgh
Washington
Memphis
Atlanta
New
Orleans
Scale
0
150

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ASSIGNMENT SHEET #1

4. Calculate the average speed of each mode using the formula:

   a. $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$

   b. Write your answers on the chart. (Figure 1)

5. Study Figure 3. Think about each type of cargo, and decide which mode of transportation you would use to transport each type of cargo from your present community to New York City. Tell why you would use it. Write your answers in the proper spaces on the following chart.

FIGURE 3

Cargo To Be Shipped	Mode	Reason
Human heart for transplant		
Lumber		
New motorcycles		
Children's clothing		
Fresh fruits		
Computers		

TRANSPORTATION SYSTEMS
UNIT V

ANSWERS TO ASSIGNMENT SHEET #1

FIGURE 1

Mode	Route	Company	Cost	Time	Distance	Average Speed
Ship	⟶	Speedy Shipping	$117.00	7 days	2025	289.3 mpd
Rail	»»»»»»	Rapid Railroad	$234.00	3½ days	1500	428.6 mpd
Truck	★★★★	Fast Trucking	$370.50	35 hrs.	1220	34.9 mph
Air	------	Lightning Air Cargo	$3750.00	2½ hrs.	1200	480 mph

FIGURE 3 — Answers will vary. All modes may not be feasible in your area. The human heart should be transported by air because of the need for speed in a life and death situation. The fresh fruits may also need to be sent by air depending on distance to New York. All other products should be sent by less expensive modes — truck, ship, or train, depending on access to these modes in your area.

TRANSPORTATION SYSTEMS
UNIT V

JOB SHEET #1 — SET UP AND OPERATE A PIPELINE SIMULATION

Different products are pumped through pipeline in "batches." Petroleum products in neighboring "batches" must have different viscosities (thicknesses). At the final destination the pure parts of each batch are ready to use, but the intermixed parts must be stored and allowed to settle. Then these can be separated and used. In this activity, you will simulate how batches of different petroleum products are shipped through a pipeline.

A. Tools and materials

1. 2 - 35 cc injectors
2. 1 - Two port aquarium valve
3. 3 - Pieces of clear, flexible plastic tubing, aquarium air line (two short pieces, one long piece)
4. 3 - glass jars, small
5. Motor oil
6. Kerosene

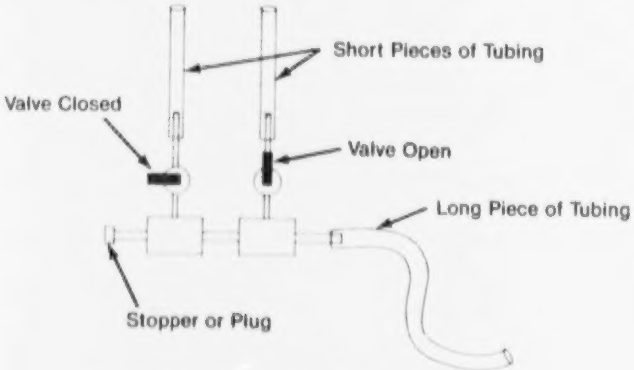
SAFETY NOTE: Follow all rules of good safety!

B. Procedure

(NOTE: Pump two batches of liquid through a line and separate the pumped liquids into three separate storage tanks: one with pure motor oil, one with intermixed motor oil and kerosene, and one with pure kerosene.)

1. Set up the valve and tubing as shown in Figure 1.

FIGURE 1

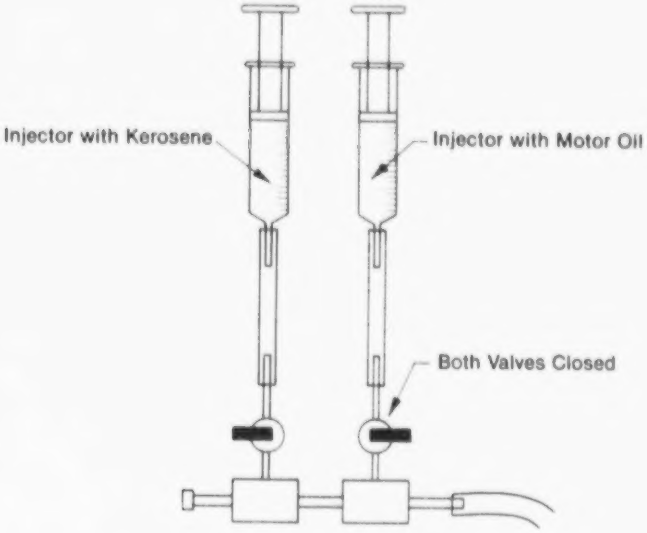


Valve and Tubing Setup

JOB SHEET #1

2. Fill one injector with 35 cc of motor oil.
3. Fill the other injector with 35 cc of kerosene.
4. Close both valves.
5. Connect each injector, carefully, to one of the short pieces of tubing as shown in Figure 2.

FIGURE 2

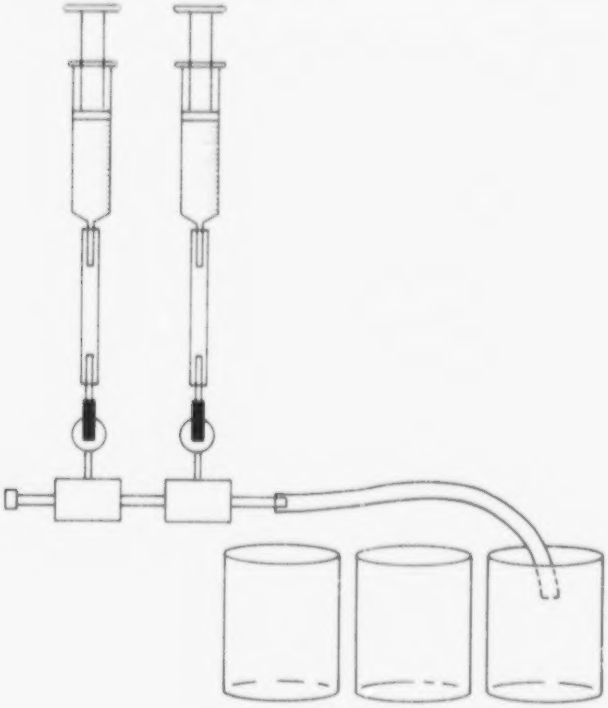

Injector with Kerosene
Injector with Motor Oil
Both Valves Closed

Connecting the Injectors

JOB SHEET #1

6. Complete setup as shown in Figure 3.

FIGURE 3



Completed Setup

7. Place the open end of the long tube (pipeline) into the first jar.

8. Open the valve below the injector containing the motor oil.

9. Push down the plunger on the injector.

10. Close the valve when the plunger is as far down as it will go.

11. Open the valve below the injector containing kerosene.

12. Push down the plunger on the injector.

(CAUTION: Closely watch the material flowing through the tube.)

13. Move the tube from the first jar into the second jar, when the intermixed material reaches the end of the tube.

14. Switch the tube into the third jar as soon as you have pure kerosene flowing through the pipeline.

JOB SHEET #1

15. Observe the materials in the jars and answer the questions:

    (NOTE: Consider the entire amount of liquid — both motor oil and kerosene — as 100%.)

    a. Estimate the percentage of liquid that is pure motor oil (amount in the first jar). ____________

    b. Estimate the percentage that is pure kerosene (third jar). ____________

    c. Estimate the percentage that is intermixed material (second jar). ____________

    d. How long did it take for the material in the second jar to settle? ____________

16. Clean, disassemble, and put away the equipment.

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TRANSPORTATION SYSTEMS
UNIT V

PRACTICAL TEST
JOB SHEET #1 — SET UP AND OPERATE A PIPELINE SIMULATION

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ____________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Set up valves and tubing.	______	______
3. Filled injectors — 1 with kerosene, 1 with motor oil.	______	______
4. Closed valves.	______	______
5. Connected injectors to short tubing.	______	______
6. Put long tube end into first jar.	______	______
7. Opened valve to motor oil and pushed plunger.	______	______
8. Closed valve to motor oil.	______	______
9. Opened valve to kerosene.	______	______
10. Pushed plunger/moved tube to second jar when intermixed material reached end of tube.	______	______
11. Switched tube to third jar when pure kerosene began flowing through pipeline.	______	______
12. Noted observations.	______	______
13. Checked in/put away tools and materials.	______	______
14. Cleaned the work area.	______	______
15. Used proper tools correctly.	______	______
16. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
17. Practiced safety rules throughout procedure.	______	______
18. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

JOB SHEET #1 PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Setup Apparatus	Assembly Consistent With Illustrated Example	Tubes Wrong Place	Tubes Too Short	Missing Equipment
	4	3	2	1
Performed Experiment	Syringe Filled Correctly/ Performed in Proper Sequence	Syringes in Wrong Order	Performed in Wrong Sequence	Did Not Switch Tube To Proper Jars
	4	3	2	1
Noted Observations	Information Recorded Neatly/ Accurately	Estimates Acceptable	Estimates Not Acceptable	Records Inaccurate/ Unacceptable

EVALUATOR'S COMMENTS: ____

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

TRANSPORTATION SYSTEMS
UNIT V

NAME ______________________________ SCORE ________________________

TEST

1. Match the terms on the right with the correct definitions.

_____a. Within the city

_____b. Between states

_____c. Solid, liquid, or gaseous material being moved from one place to another

_____d. People who are being transported from place to place

_____e. The beginning and ending points for loading and unloading passengers and cargo

_____f. The movement of people and materials

_____g. Transportation devices

_____h. Moving passengers or cargo using more than one mode or method

_____i. Moving people and/or materials over short distances within one particular area or building

1. Vehicles
2. Terminals
3. Intrastate
4. Interstate
5. Cargo/freight
6. Intercity
7. Intracity
8. Passengers
9. Transportation
10. On-site transportation
11. Intermodal transportation

2. List the four basic modes of transportation.

a. ____

b. ____

c. ____

d. ____

TEST

3. Match types of intermodal transportation on the right with the correct uses.

_____a. Shipping goods in large boxes, which can be filled at one location, transported via different modes, and delivered to its destination without rehandling the goods

_____a. The middle persons in transportation who collect small loads from shippers, consolidate them into a large load, and send the large load to the next receiver

_____a. The delivery of packages or parcels in the fastest and most direct way possible

1. Small package express service
2. Containerization
3. Freight forwarders

4. Complete the following statements concerning types of on-site transportation by supplying the appropriate word or words from the box on the right.

a. People-moving — Movement of _____________ inside the building using _____________ and other equipment.

b. Materials-handling — Movement of _____________ inside the building using _____________ and other equipment.

Automobiles
Conveyors
Escalators
Individuals
Products

5. Complete the following statements concerning highway transportation by circling the correct words.

a. Buses and taxis are primarily used for (**personal, commercial**) transportation of people.

b. Automobiles are primarily used for (**personal, commercial**) transportation of people and materials.

TEST

6. Complete statements concerning rail transportation by suppling the correct word from the word box.

   a. Rail transportation is primarily used for commercial transportation of passengers and freight over ______________ distances.

   b. An example of a commercial passenger line is ______________.

   c. An example of a commercial freight line is ______________.

   d. A railway has four parts — Right-of-way land, ballast, ties (or cross-ties) and ______________.

   e. Stations are for loading and unloading ______________.

   f. Freight ______________ are for loading and unloading freight.

   g. ______________ are complexes of tracks for joining railroad cars or for breaking up and regrouping cars to make more efficient use of the railways.

   h. ______________ are for monitoring the switching of trains and cars by dispatchers.

   i. Engine/car shops are for major ______________ and maintenance work.

Amtrak

Classification yards

Control centers

Long

Passengers

Rails

Repairs

Santa Fe

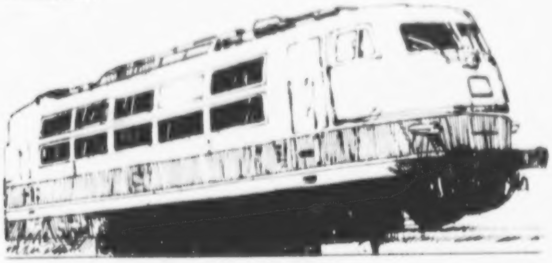
Short

Systems

Terminals

7. Identify types of railway vehicles by placing the correct number in the appropriate blank.

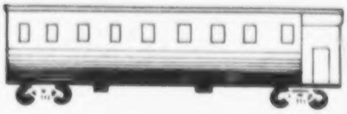
______a.



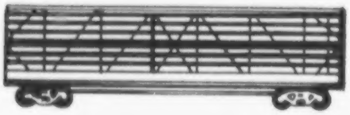
1. Freight car
2. Locomotive
3. Passenger car

TEST

______b.



______c.



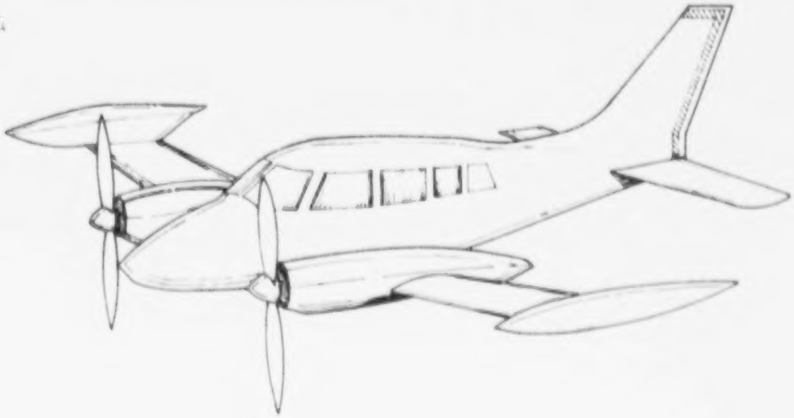
8. Match types of commercial airlines on the right with the correct descriptions.

______a.	Charter planes	1. Domestic
______b.	Fly between U.S. and other countries	2. International
______c.	Fly to and from major airports of the U.S.	3. Nonscheduled
______d.	Fly only specific regions of the U.S.	4. Regional
______e.	Fly from smaller towns and cities to major airports in the U.S.	5. Commuter

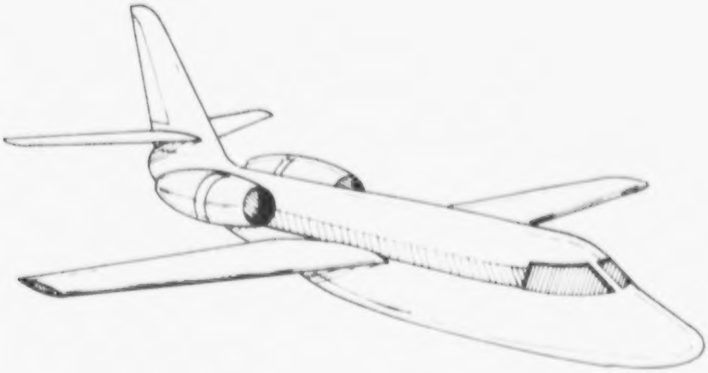
TEST

9. Distinguish between the basic types of airplanes by placing an "X" next to the illustration of a jet plane and an "O" next to the prop plane.

_____a.

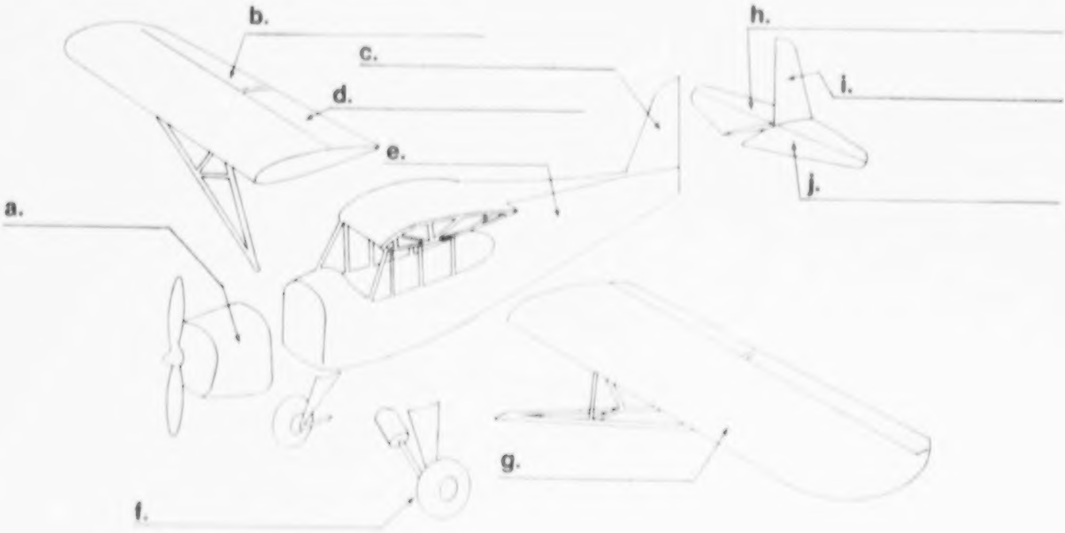


_____b.



TEST

10. Identify parts of an airplane by placing the appropriate answers in the blanks. Choose your answers from the following: Aileron, elevator, engine, flap, fuselage, horizontal stabilizer, landing gear, rudder, vertical stabilizer, wing.



11. Complete statements concerning space transportation by circling the correct words.

   a. Space transportation is an exploration of the region (**inside, outside**) the earth's atmosphere.

   b. Use (**jet, rocket**) engines which carry their own fuel and oxygen supplies.

   c. Use (**small, large**) launch vehicles to place spacecraft into orbit.

   d. The first man-made satellite was put into orbit on October 4, (**1957, 1967**) by the U.S.S.R.

   e. The first man-made satellite was called (**Telstar, Sputnik**).

   f. Unmanned space vehicles are used for communication, (**weather, political**) forecasting, and military reconnaisance.

   g. The first person in space, Russian cosmonaut Yuri Gagarin, orbited the earth (**1 time, 10 times**).

   h. The United States followed closely after this with manned flights by American astronauts Alan Shepherd, Virgil Grissom, and (**John Glenn, Glenn Ford**).

TEST

12. Match U.S. space projects on the right with their correct contributions.

______a. Orbited astronauts around the earth; had ten, two-manned flights

______b. Made transition from space exploration to space utilization; was a space station for experiments

______c. Put first Americans on the moon (1969)

______d. Developed a space vehicle that could be reused

______e. Put first American in space; had six, one-manned flights

1. Apollo
2. Gemini
3. Mercury
4. Skylab
5. Space shuttle

13. Complete statements concerning the characteristics of the space shuttle by circling the appropriate words.

a. The orbiter (**is, is not**) reusable.

b. The external tank holds the (**liquid, solid**) propellants for the main engines.

c. There are (**2, 4**) solid rocket boosters.

d. Shuttle is launched (**horizontally, vertically**).

e. The shuttle can carry up to (**2, 7**) people into orbit and up to 65,000 lbs. of cargo such as satellites, replacement parts, and other equipment. It also has a manipulator arm that serves many functions, including retrieving satellites in need of repair.

f. The shuttle reenters the atmosphere and lands (**as a glider, in the ocean**).

14. Match basic vessels for water transportation on the right with the correct descriptions.

______a. Smaller watercraft propelled by oars, sails, or engines for recreational or commercial use

______b. Hydrofoils and hovercrafts

______c. Larger watercraft propelled by engines for commercial transportation of people or cargo

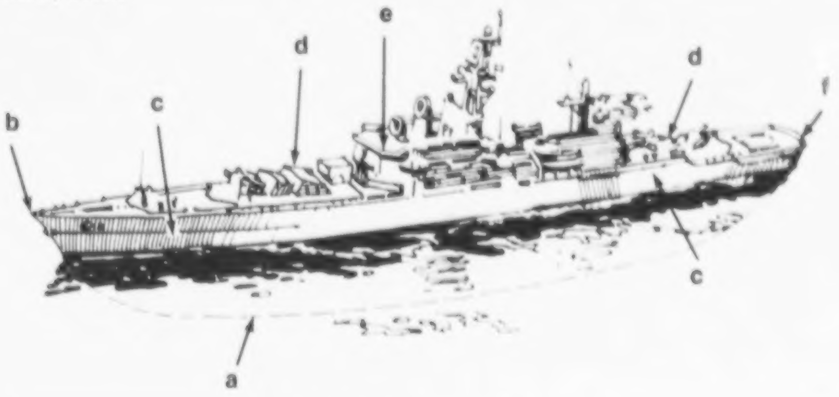
______d. Flat, commercial cargo vessels that are pushed or pulled by engine-driven vessels (tugboats or towboats)

______e. Vessels used by U.S. armed forces (especially the Navy) for defense and service of the country

1. Barges
2. Boats
3. Military vessels
4. Ships
5. Specialized craft

TEST

15. Identify the basic parts of a ship by placing the correct answers on the blanks provided. Select your answers from the following list: Bow, bridge, deck, hull, keel, port, starboard, stern



a. ______________________ b. ______________________

c. ______________________ d. ______________________

e. ______________________ f. ______________________

16. List two uses of computers for each of the following transportation systems.

a. Highway transportation

1) ______________________________

2) ______________________________

b. Rail transportation

1) ______________________________

2) ______________________________

c. Air transportation

1) ______________________________

2) ______________________________

d. Space transportation

1) ______________________________

2) ______________________________

TEST

e. Water transportation

1) ________________________________

2) ________________________________

f. Stationary transportation

1) ________________________________

2) ________________________________

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

17. Select modes of transportation for given situations. (Assignment Sheet #1)

18. Demonstrate the ability to set up and operate a pipeline simulation. (Job Sheet #1)

TRANSPORTATION SYSTEMS
UNIT V

ANSWERS TO TEST

1. a. 7
   b. 4
   c. 5
   d. 8
   e. 2
   f. 9
   g. 1
   h. 11
   i. 10

2. a. Land
   b. Water
   c. Air
   d. Space

3. a. 2
   b. 3
   c. 1

4. a. Individuals, escalators
   b. Products, conveyors

5. a. Commercial
   b. Personal

6. a. Long
   b. Amtrak
   c. Santa Fe
   d. Rails
   e. Passengers
   f. Terminals
   g. Classification yards
   h. Control centers
   i. Repairs

7. a. 2
   b. 3
   c. 1

8. a. 3
   b. 2
   c. 1
   d. 4
   e. 5

9. a. O
   b. X

ANSWERS TO TEST

10. a. Engine
    b. Aileron
    c. Vertical stabilizer
    d. Flap
    e. Fuselage
    f. Landing gear
    g. Wing
    h. Horizontal stabilizer
    i. Rudder
    j. Elevator

11. a. Outside
    b. Rocket
    c. Large
    d. 1957
    e. Sputnik
    f. Weather
    g. 1 time
    h. John Glenn

12. a. 2
    b. 4
    c. 1
    d. 5
    e. 3

13. a. Is
    b. Liquid
    c. 2
    d. Vertically
    e. 7
    f. As a glider

14. a. 2
    b. 5
    c. 4
    d. 1
    e. 3

15. a. Keel
    b. Bow
    c. Hull
    d. Deck
    e. Bridge
    f. Stern

ANSWERS TO TEST

16. Any two uses from each of the following areas:
    a. Highway transportation
        1) Vehicle production and assembly
        2) Computerized ignition systems
        3) Computerized diagnostic and test equipment
        4) Computer controlled traffic flow
        5) Law enforcement
        6) Trucking company recordkeeping
    b. Rail transportation
        1) Customer billing
        2) Reservations on passengers trains
        3) Switching operations
        4) Car identification
    c. Air transportation
        1) Airplane design
        2) Air traffic control
        3) Airplane gauges and controls
        4) Airline reservations
    d. Space transportation
        1) Tracking space vehicles
        2) On-board navigation guidance systems
        3) On-board communication systems
        4) Life support monitoring
        5) Launching operations
    e. Water transportation
        1) Navigation
        2) Scheduling passengers or cargo
    f. Stationary transportation
        1) Controlling speed and distribution of products for pipelines and conveyors
        2) Monitoring load requirements in elevators and escalators

17. Evaluated to the satisfaction of the instructor

18. Performance skills evaluated to the satisfaction of the instructor

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between the six technical subsystems and design and build a model racer. Competencies will be demonstrated by completing the assignment sheets, job sheet, and unit tests with a minimum of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to transportation technical subsystems with the correct definitions.
2. Match types of transportation technical subsystems with the correct descriptions.
3. Complete statements concerning the elements of propulsion.
4. Match types of suspension systems with the correct descriptions.
5. Complete statements concerning types of control systems.
6. Distinguish between guidance systems.
7. List considerations of structural systems.
8. Complete statements concerning support systems.
9. Identify technical subsystems. (Assignment Sheet #1)
10. Design a model racer. (Assignment Sheet #2)
11. Demonstrate the ability to build a model racer. (Job Sheet #1)

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Provide students with objective sheet.

C. Discuss unit and specific objectives.

D. Provide students with information and assignment sheets.

E. Discuss information and assignment sheets.

F. Provide students with job sheet.

G. Discuss and demonstrate the procedure outlined in the job sheet.

H. Integrate the following activities throughout the teaching of this unit:

   1. Have students participate in the student organization activity to build $^1/_{10}$ scale radio-controlled cars.

   2. Have students compare the technical subsystems of the automobile and the bicycle for similarities and differences.

   3. Discuss the authority and responsibilities of the many state and federal regulatory agencies for transportation.

      Examples: FAA, ICC, FRA

   4. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

I. Give test.

J. Evaluate test.

K. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Berghauser, Thomas and Michael Kozak. *Systems of Technology: Laboratory Activities in Energy.* Austin, Texas: EIMC, 1986.

B. Bohn, Ralph C., et. al. *Energy, Power, and Transportation Technology.* Peoria, IL: Bennett & McKnight Publishing Co., 1986.

C. Hughes, Larry R. *Energy Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

D. Hughes, Larry R. and Alan L. Towler. *Transportation Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

E. *Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers.* Thomas Wright and Len Sterry, Co-Directors. Lansing, IL: Technical Foundation of America.

F. Johnson, Jim. *Laser Technology: An Individual Learning Course.* Benton Harbor, MI: Heath Company, 1985.

G. *Principles of Technology: Energy.* Waco, Texas: Center for Occupational Research and Development, 1985.

H. *North Dakota Senior High Industrial Arts Curriculum Guide: Transportation.* Myron Bender, Project Director. North Dakota State Board for Vocational Education, 1981.

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

INFORMATION SHEET

I. **Terms and definitions**

  A. Guidance — Directing a body's course of travel

  B. Guideways — Pathways for transportation vehicles

  C. Linear induction — A magnetic coil is attached to the vehicle and the "rotor" becomes the rails along which the train moves

  D. MagLev train — Magnetically levitated system where a magnetic force lifts the train above the track and then pushes it forward by another power source

  E. Propulsion — Moving a body forward

  F. Suspension — Support of a framework

II. **Types of transportation technical subsystems** (Transparency 1)

  A. Propulsion — Process of causing a body to move by exerting a natural or mechanical force

  B. Suspension — Methods employed to suspend a vehicle in or on a given environmental medium

  C. Control — Mechanical or automated procedures used to control a vehicle and/or vehicular system

  D. Guidance — Information required to operate a vehicle or vehicular system in a prescribed path

  E. Structure — Structural makeup and design of vehicles and other systems' physical components

  F. Support — Operation, maintenance, and regulation of total system

III. **Elements of propulsion** (Transparency 2)

  (NOTE: These elements work as a system to propel the transportation vehicle.)

  A. Energy sources — Chemical, electrical, heat, light, nuclear, mechanical

  B. Energy converters — Internal and external combustion engines, generators, motors

  C. Power converters and transmitters

    1. Mechanical power — Uses gears, belts, chains, and pulleys to transmit power

INFORMATION SHEET

2. Fluid power — Uses pressurized gases or liquids to transmit power through tubes and hoses

3. Electrical power — Uses conducting wires or air and electrical control devices to transmit power

IV. **Types of suspension systems** (Transparency 3)

A. Mechanical suspension — Uses mechanical devices for suspension

Examples: Wheels on rails, wheels on highways

B. Magnetic suspension — Uses permanent magnets or electromagnets for suspension

Example: MagLev Train

C. Fluid suspension — Uses air (aero) or water (hydro) systems for suspension

Examples: Hydrofoils, airplanes, hot air balloons

1. Aerostatic — Force exerted when gases are in equilibrium

2. Hydrostatic — Force exerted when liquids are in equilibrium

3. Hydrodynamic — Force exerted by liquids in motion

4. Aerodynamic — Forces exerted by gases in motion

V. **Types of control systems** (Transparency 4)

A. Vehicular controls

1. On-off (arresting) control devices — Examples include brakes, air flaps, and on-off switches.

2. Direction, force, and speed control devices — Examples include rudders, steering wheels, accelerators, and electronic monitors.

B. System controls

1. On-off control devices — Examples include clutches and brakes on mechanical systems, gate and globe valves on fluid systems, and switches on electrical systems.

2. Direction, force, and speed control devices — Examples include gears and pulleys on mechanical systems, check valves and control/relief valves on fluid systems, and diodes, fuses, and transformers on electrical systems.

(NOTE: Control devices may be manually or electronically activated from either local or remote locations.)

INFORMATION SHEET

VI. **Guidance systems** (Transparency 5)

  A. Physical guideways — Highways, rails, tubes, canals, and cables

  B. On-board and external guidance devices and systems — Includes sensing devices, coding systems, signals, transmitting and receiving systems, and storage and retrieval systems.

    1. On-board — Examples include radios, speedometers, gauges, electronic sensors, automatic pilot, radar, and computers.

    2. External guidance — Examples include traffic lights, highway signs, water navigation markers, railroad signals, radar, and computers.

VII. **Structural systems** (Transparency 6)

  A. Structure of vehicle

    1. Materials used for constructing vehicle

       Examples: Steel, aluminum, fiberglass

    2. Methods of constructing vehicle

       Examples: Welding, riveting, molding, forging

    3. Design considerations

       Examples: Purpose of vehicle, performance, safety, cost

  B. Structure of guideways

    1. Materials used for constructing guideways

       Examples: Steel, concrete

    2. Methods of constructing guideways

       Examples: Pouring concrete, welding, riveting

    3. Design considerations

       Examples: Purpose of guideway, environmental impact, safety, cost

INFORMATION SHEET

VIII. **Support systems** (Transparency 7)

A. Physical service and maintenance facilities

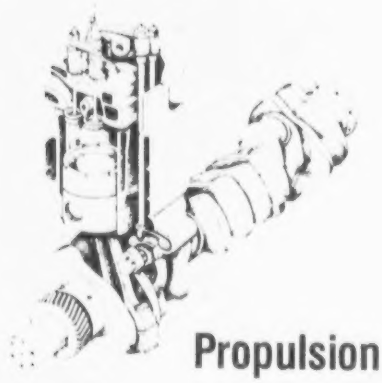
1. Terminals
2. Repair shops
3. Loading/unloading docks

B. Personnel — All employees involved in transportation industries including management and support personnel

C. Regulations — All state and federal regulatory agencies which issue the licenses and enforce the laws and regulations of transportation industries

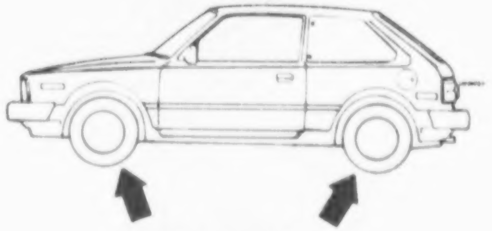
Examples: Federal Aviation Administration (FAA), department of transportation (state and federal), U.S. Coast Guard, Army Corps of Engineers, Civil Aeronautics Board, Interstate Commerce Commission, Federal Highway Administration, Federal Railroad Administration

Transportation Technical Subsystems

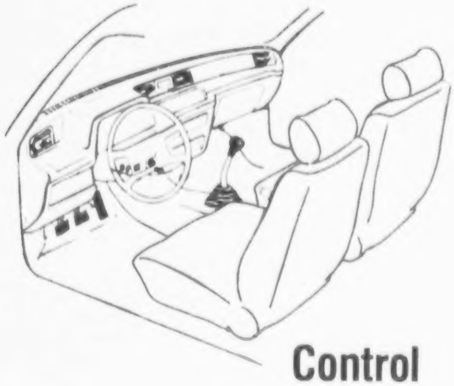


Propulsion

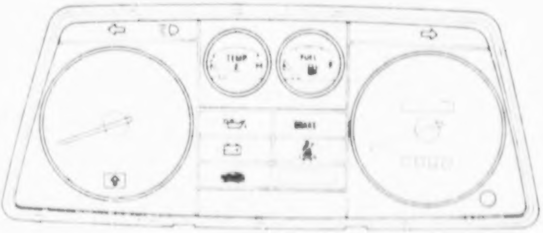
Structure



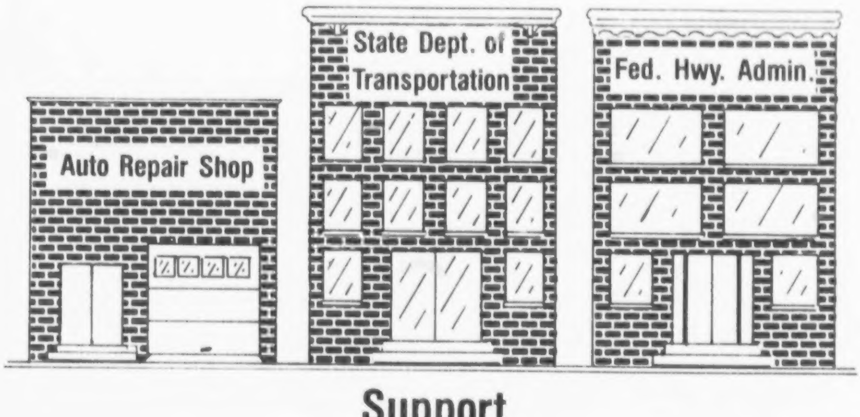
Suspension



Control

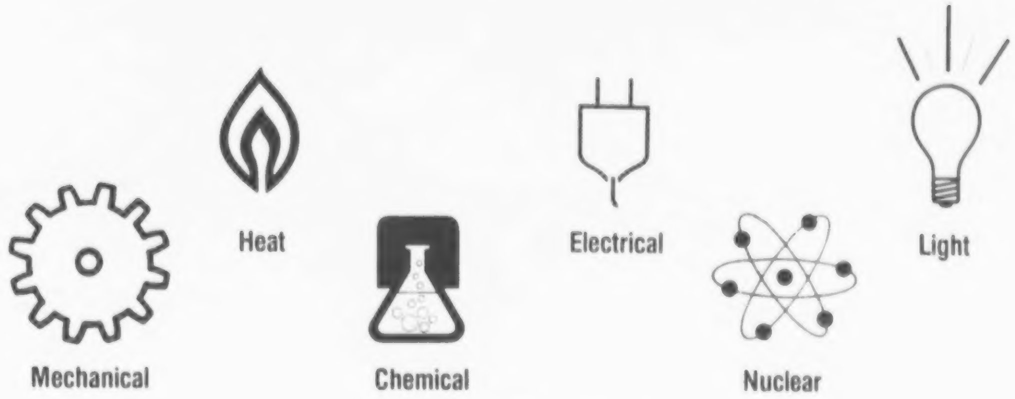


Guidance

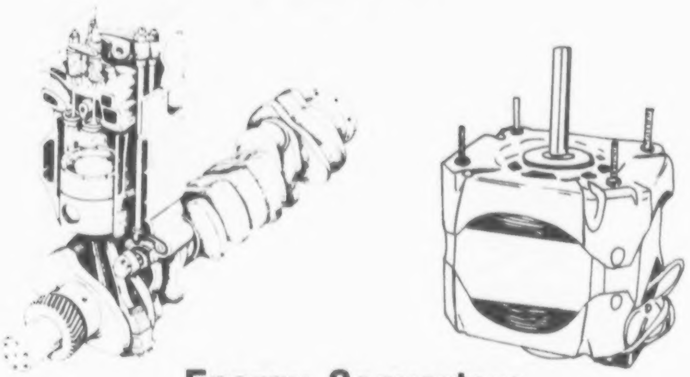

State Dept. of Transportation
Fed. Hwy. Admin.
Auto Repair Shop

Support

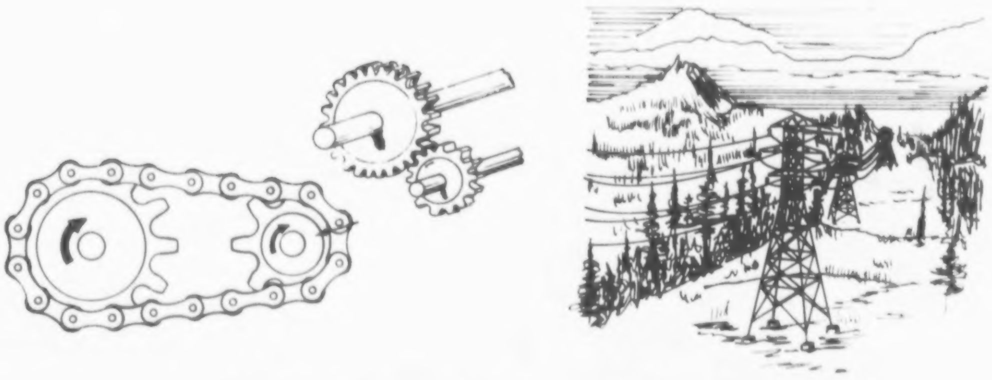
Elements of Propulsion


Heat
Electrical
Light
Mechanical
Chemical
Nuclear

Energy Sources

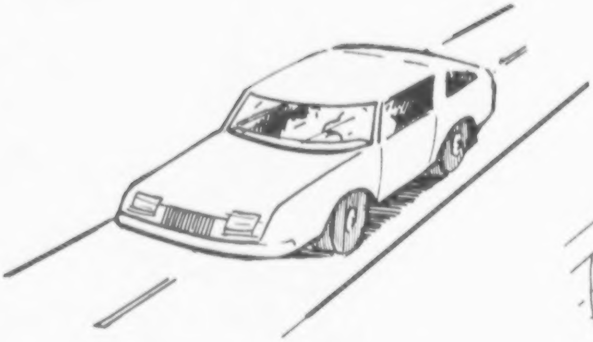


Energy Converters

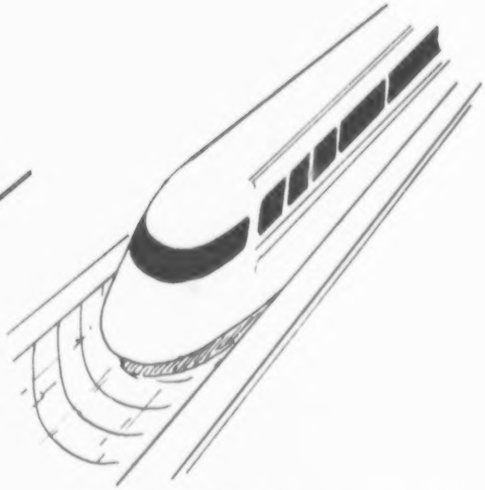


Power Converters and Transmitters

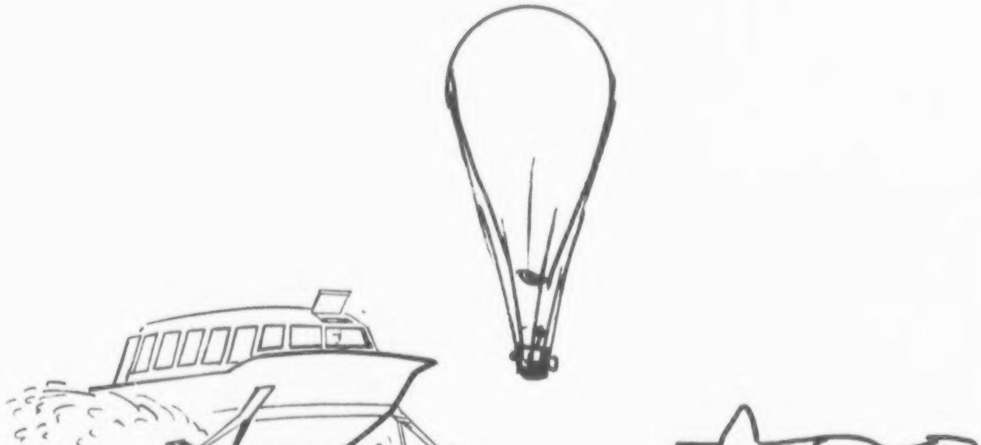
Suspension Systems



Mechanical Suspension

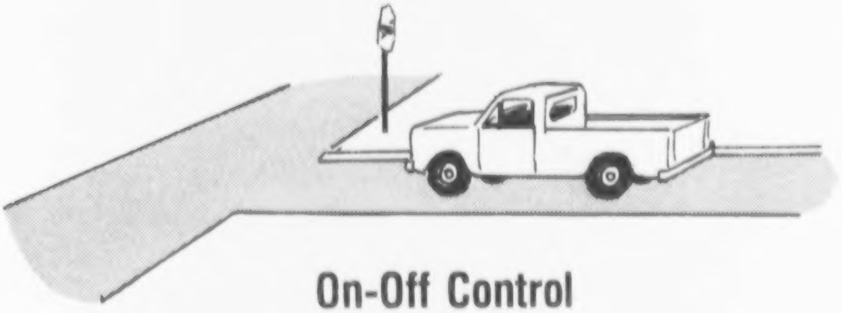


Magnetic Suspension

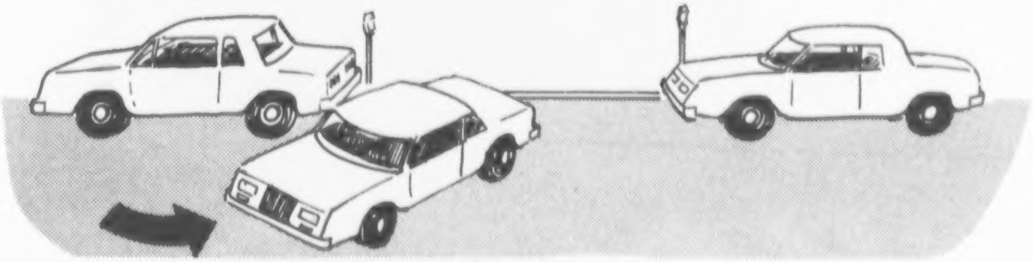


Fluid Suspension

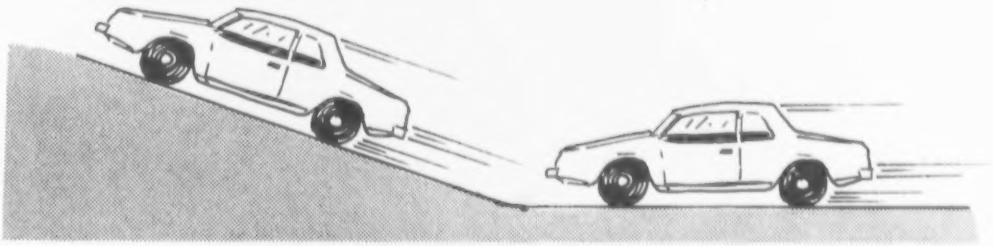
Control Devices



On-Off Control

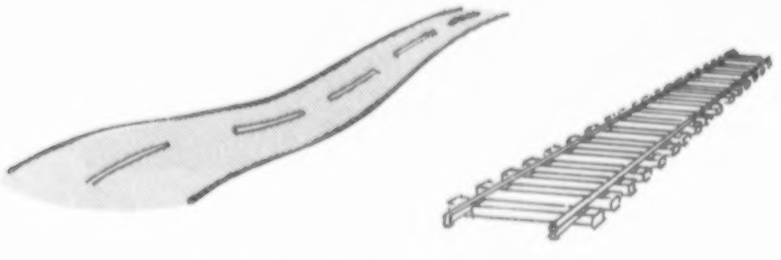


Direction Control

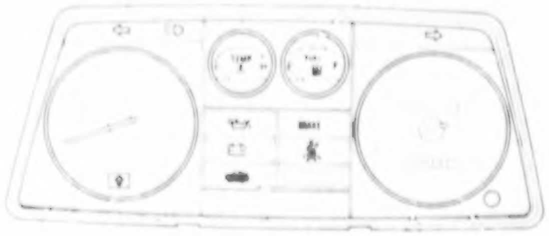


Force and Speed Control

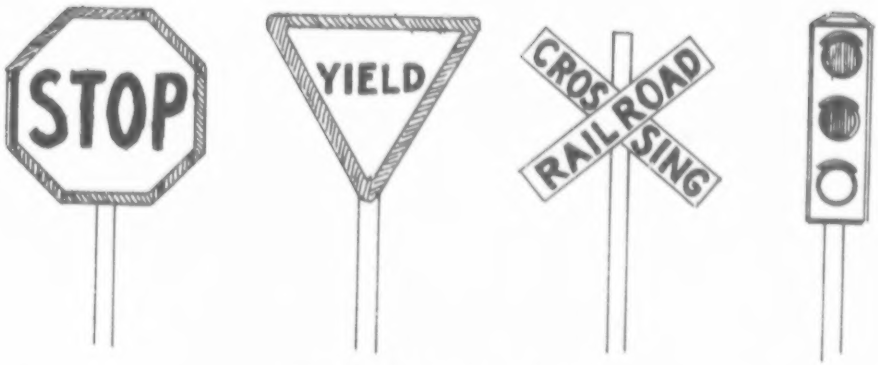
Guidance Systems



Physical Guideways

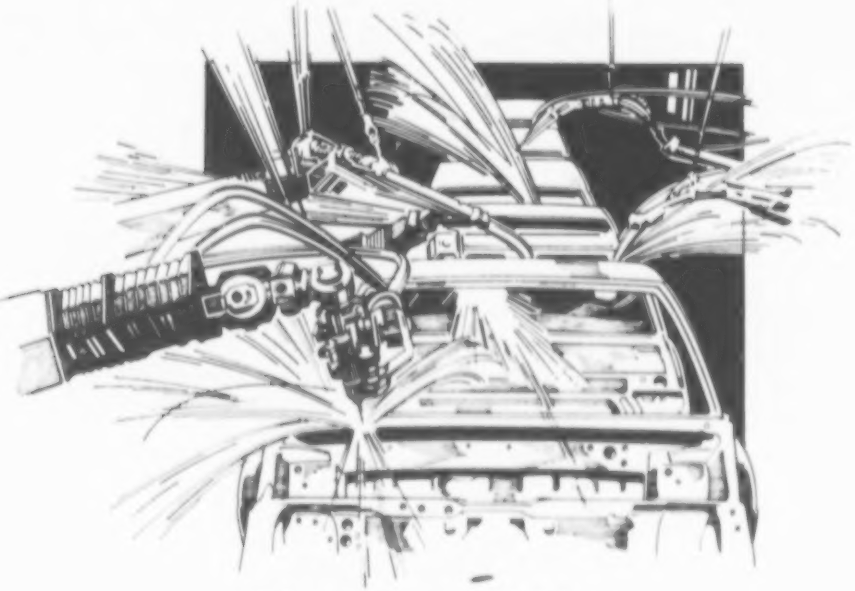


On-Board Guidance

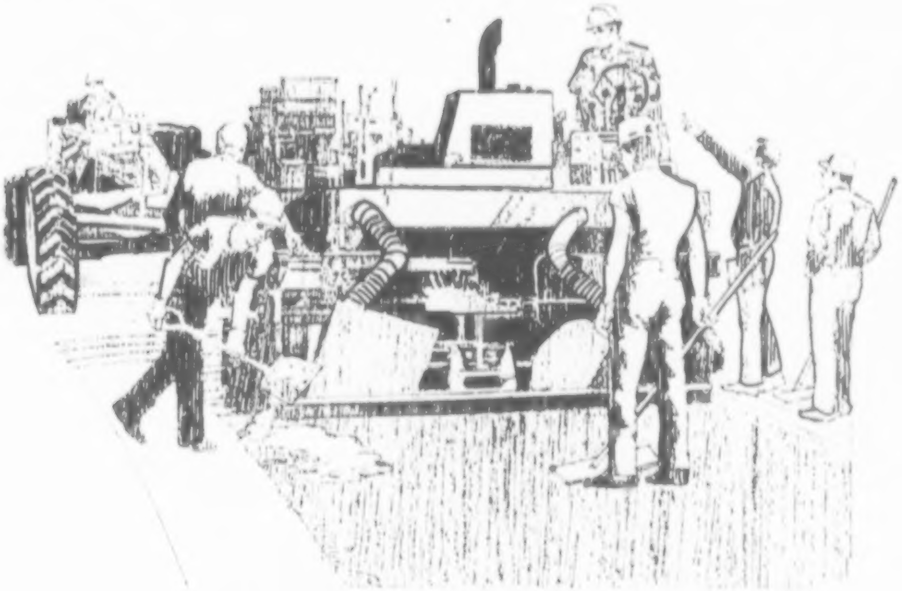

STOP
YIELD
RAILROAD
CROSSING

External Guidance

Structural Systems

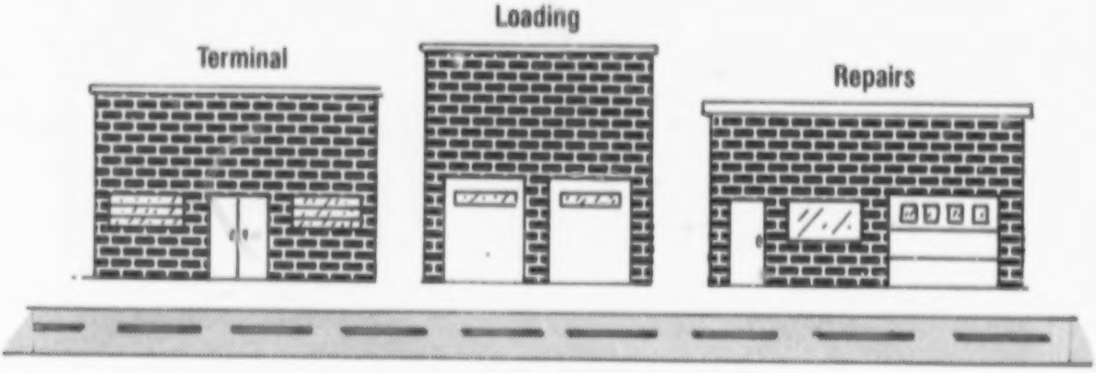


Structure of Vehicle



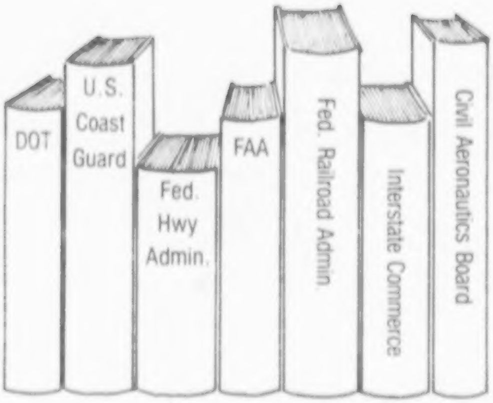
Structure of Guideways

Support Systems


Terminal
Loading
Repairs

Service and Maintenance Facilities

Personnel


DOT
U.S. Coast Guard
Fed. Hwy Admin.
FAA
Fed. Railroad Admin.
Interstate Commerce
Civil Aeronautics Board

Regulations

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

ASSIGNMENT SHEET #1 — IDENTIFY TECHNICAL SUBSYSTEMS

NAME ______________________________ SCORE __________

Directions: Choose a vehicle system and identify the technical subsystems used by that vehicle.

Vehicle System: ______________________________

1. **Propulsion system** (What are the energy sources used and how are they converted to power and transmitted?)

   ____

   ____

   ____

2. **Suspension system** (What type of suspension system is used, what parts are involved?)

   ____

   ____

   ____

3. **Control system** (What control devices are used in the vehicle and what control devices are used for the overall system?)

   ____

   ____

   ____

4. **Guidance system** (What devices are used for physical, on-board, and external guidance?)

   ____

   ____

   ____

ASSIGNMENT SHEET #1

5. **Structural system** (What materials and methods were used to construct the vehicle and the guideways?)

6. **Support system** (What facilities, personnel, and regulations are used to support the vehicle system?

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

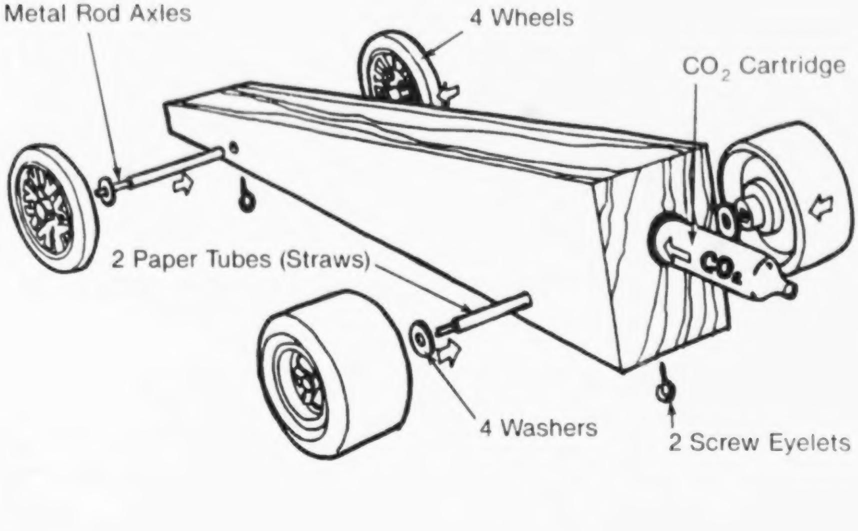
ASSIGNMENT SHEET #2 — DESIGN A MODEL RACER

NAME ______________________________ SCORE ____________

Directions: Design a model racer using the specifications on the attached sheet for maximum and minimum dimensions.

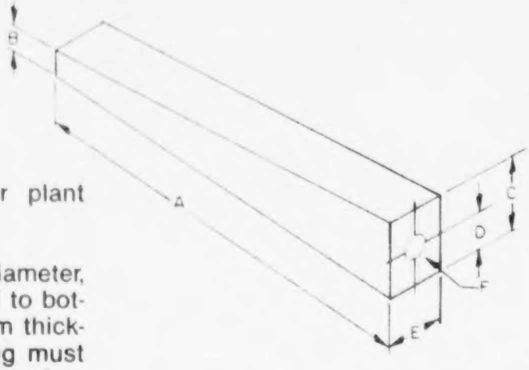
(NOTE: This would be the appropriate time to decide whether to obtain a kit form or to do the complete process.)

1. Design the rough sketch.
2. Draw the final sketch.
3. Check for correct specifications.


Metal Rod Axles
4 Wheels
CO_2 Cartridge
2 Paper Tubes (Straws)
CO_2
4 Washers
2 Screw Eyelets

ASSIGNMENT SHEET #2

Race Car Specifications



1. Maximum dimensions for Body Blank.
   - A. Length — 305 mm.
   - B. Front height — 20 mm.
   - C. Rear height — 70 mm.
   - D. Bottom to centerline of power plant chamber — 35 mm.
   - E. Width — 42 mm.
   - F. Power Plant Chamber — 20 mm diameter, 51 mm depth, and drilled parallel to bottom surface. A minimum of 3 mm thickness around power plant housing must be maintained on all race cars for safety purposes. The position of the power plant must be as shown in the drawing.
   - G. The body of the model shall be one piece all-wood construction, and no parts (such as body strengtheners, fenders, plastic canopy, exhausts, or air foils) may be attached to or enclosed within the race cars. Bearings and lubricants may be used in construction.

2. Related dimensions[1].

	Maximum	**Minimum**
Axles (diam.)	3 mm	3 mm
Axles (length)	70 mm	42 mm
Axles Bearing (diam.)	4.5 mm	3.5 mm
Axle Hole (diam.)	4.5 mm	3.5 mm
Axle Hole (position above body bottom)	9 mm	7 mm
Axle Hole (position from either end of body)	10 mm	9 mm
Brass Spacer Bearing (diam.)	9 mm	8 mm
Body (length)	305 mm	200 mm
Body (height at rear with wheels)	75 mm	56 mm
Body (mass with wheels)	170.10 g	30 g
Body (width at axles)	42 mm	35 mm
Power Plant Housing (diam.)	20 mm	19 mm
Power Plant C/L[2] (from body bottom)	35 mm	31 mm
Screw Eye (eyelet inside diam.)	5 mm	3 mm
Screw Eyes (2) on C/L[2] of bottom, distance apart	270 mm	155 mm
Wheels, Front (diam.)	37 mm	32 mm
Wheels, Front (width at greatest diam.)	5 mm	2 mm
Wheels, Rear (diam.)	46 mm	36 mm
Wheels, Rear (width at greatest diam.)	18 mm	15 mm
Wheelbase	270 mm	105 mm

[1] Assembled without CO_2 cartridge

[2] Centerline

3. Wheels are to be made entirely from plastic.

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

JOB SHEET #1 — BUILD A MODEL RACER

A. Tools and materials

1. Wood block (1 5/8" × 2 3/4" × 12") or (42 mm × 70 mm × 300 mm)
2. Templates and carbon paper
3. Pencil
4. Masking tape
5. Rubber bands
6. 1 - half round cabinet file
7. Coarse, medium, and fine sandpaper
8. Pliers
9. Scratch awl
10. 3/16" twist bit
11. Half round wood rasp
12. C-clamps
13. Hand drill or drill press*
14. Scroll saw, coping saw, or bandsaw*

    (NOTE: *If power tools are used, have your teacher explain the proper and safe use before going any further. BE CAREFUL and FOLLOW SAFETY PRECAUTIONS!)

15. 3/4" spade bit

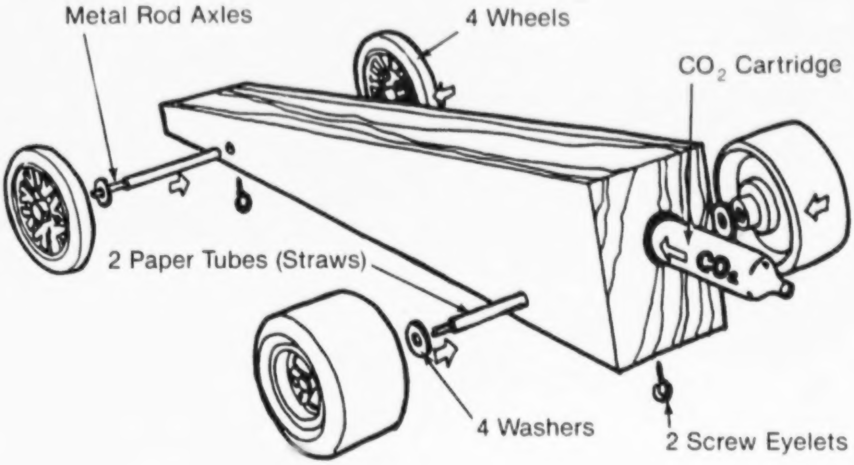
    (NOTE: Entire kit may be purchased from Pitsco, Inc., Box 1328, Pittsburg, KS 66762.)

16. Screw eyes (2)
17. Straw tubes
18. Washers (4)
19. Plastic wheels (2 front, 2 rear)

JOB SHEET #1

20. Axles (Two 1/8" metal rod axles)

FIGURE 1



B. Procedure

1. Complete Assignment Sheet #2 on designing the racer.
2. Make a rough sketch showing two views of your car.
3. Using a grid sheet, draw a full scale model of your car (top and side).

   (NOTE: Students should check drawings at this point for the following:

   ☐ Is the front axle in the correct position?

   ☐ Is rear axle in the correct position?

   ☐ Is there sufficient room for CO $_2$ cartridge to fit in correct position?

   ☐ Does design fit within the height, width, and length dimensions allowed in Assignment Sheet #2?

4. Place drawing and carbon paper together and cut out drawing and carbon paper with scissors.

   (NOTE: These are templates or pattern pieces.)

5. Tape side-view template onto wooden block and trace around template with pencil; remove template.
6. Tape the top-view template to the bottom of the block and trace around template with pencil; remove template.

JOB SHEET #1

7. Mark axle locations.

8. Drill axle holes.

   (NOTE: Check limitations for correct position. Have instructor's approval before using any power equipment!)

9. Drill hole for CO_2 engine cartridge.

   (NOTE: Check limitation guides for exact placement.)

10. Cut the patterns using coping saw or bandsaw.

11. Shape the top view using wood rasp and a file.

12. Smooth body by sanding.

    (NOTE: First use coarse (60 grit) sandpaper, then medium sandpaper (100 grit).)

13. Cut and install soda straw bearings.

14. Place washers in position.

15. Force wheels on axles.

16. Check wheels for secure attachment and to see that axles turn freely.

17. Determine exact location of screw eyes (see Figure 1).

18. Make holes using a scratch awl. Use pliers to insert and tighten screw eyes.

19. Look through screw eyes to check for interference.

20. Sand and smooth body (starting with 150 grit and finishing with 220 grit, after removing wheels, axles, and screw eyes).

21. When car feels smooth, paint with a fast drying spray paint, at least two coats.

    (NOTE: Car should be placed on a dowel rod, inserted in engine hole to allow free access.)

22. Check paint for flaws, and make repairs if needed.

23. Place decals and numerals in proper place.

24. Reinsert wheels, axles, and screw eyes.

    (NOTE: Check wheels for flaws. Use fine sandpaper to smooth any bumps or irregularities. Graphite may be rubbed along axle to allow faster turning.)

25. Test car.

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

PRACTICAL TEST
JOB SHEET #1 — BUILD A MODEL RACER

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Completed assignment sheet on designing.	______	______
3. Made rough sketches and drawings (full scale) of car (two views).	______	______
4. Placed drawing and carbon together and cut out with scissors.	______	______
5. Taped and traced side and top templates onto car.	______	______
6. Marked axle locations, and drilled axle holes and hole for CO_2 engine.	______	______
7. Cut out car with coping or band saw.	______	______
8. Shaped top view with wood rasp and file and smoothed body by sanding.	______	______
9. Cut and installed soda straw bearings, placed washers in position, and forced wheels on axles.	______	______
10. Checked wheels for secure attachment and free wheeling.	______	______
11. Determined and marked location for screw eyes, and made holes with scratch awl in screw eyes.	______	______
12. Checked screw eyes for interference.	______	______
13. Sanded and painted body, and placed decals and numerals.	______	______
14. Reinserted wheels, axles, and screw eyes.	______	______
15. Tested car.	______	______
16. Checked in/put away tools and materials.	______	______
17. Cleaned the work area.	______	______

EVALUATOR'S COMMENTS: ____

____

PRACTICAL TEST

PRODUCT EVALUATION

(EVALUATOR NOTE: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Design	Designed within specifications	Eyelets too close	Axles incorrect	Car too short
	4	3	2	1
Production	Axle/Power plant within specifications	Too heavy	Cartridge housing below minimum	Cut into power plant
	4	3	2	1
Finishing	Smooth/ No flaws	Sealed and sanded	Needs sanding	Needs filing
	4	3	2	1
Testing	Time/ Performance OK	Axles require lubrication	Wheels out of balance	Eyelets not secure

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(EVALUATOR NOTE: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

NAME ______________________________ SCORE ________________________

TEST

1. Match the terms on the right with the correct definitions.

______a. Directing a body's course of travel

______b. Pathways for transportation vehicles

______c. A magnetic coil is attached to the vehicle and the "rotor" becomes the rails along which the train moves

______d. Magnetically levitated system where a magnetic force lifts the train above the track and then pushes it forward by another power source

______e. Moving a body forward

______f. Support of a framework

1. MagLev train
2. Suspension
3. Guideways
4. Propulsion
5. Guidance
6. Linear induction

2. Match the types of transportation technical subsystems on the right with the correct descriptions.

______a. Process of causing a body to move by exerting a natural or mechanical force

______b. Methods employed to suspend a vehicle in or on a given environmental medium

______c. Mechanical or automated procedures used to control a vehicle and/or vehicular system

______d. Information required to operate a vehicle or vehicular system in a prescribed path

______e. Structural makeup and design of vehicles and other systems' physical components

______f. Operation, maintenance, and regulation of total system

1. Structure
2. Guidance
3. Propulsion
4. Suspension
5. Support
6. Control

TEST

3. Complete statements concerning the elements of propulsion by filling in the appropriate word(s) in the blanks.

   a. Energy ____________ — Chemical, electrical, heat, light, nuclear, mechanical

   b. Energy ____________ — Internal and external combustion engines, generators, motors

   c. ____________ power — Uses gears, belts, chains, and pulleys to transmit power

   d. ____________ power — Uses pressurized gases or liquids to transmit power through tubes and hoses

   e. ____________ power — Uses conducting wires or air and electrical control devices to transmit power

   Converters
   Electrical
   Fluid
   Mechanical
   Sources
   Transmitters

4. Match types of suspension systems on the right with their correct descriptions.

   _____a. Uses devices such as wheels and axles for suspension

   _____b. Uses permanent magnets or electromagnets for suspension

   _____c. Uses air or water systems for suspension

   1. Magnetic suspension
   2. Fluid suspension
   3. Mechanical suspension

5. Complete the following statements concerning types of control systems by circling the correct words.

   a. An example of an on-off control device on a vehicle is (**brakes, steering wheels**).

   b. An example of a device for controlling direction on a vehicle is (**air flaps, rudders**).

   c. An example of an on-off control device on a fluid power system is (**fuses, globe valves**).

   d. Switches are used on electrical systems for (**on-off, direction, force**) control.

6. Distinguish between guidance systems by writing a "P" for physical and "O/E" for onboard and external guidance systems in the appropriate blank.

   _____a. Highways, rails, tubes, canals, and cables

   _____b. Sensing devices, coding systems, signals, transmitting and receiving systems, and storage and retrieval systems

TEST

7. List the three considerations for the structural systems of both vehicles and guideways.

   a. ______________________________

   b. ______________________________

   c. ______________________________

8. Complete the following statements concerning support systems by correctly filling in the appropriate word(s) in the blank.

   a. Physical service and maintenance facilities used for support include ____________, ____________, and loading/unloading docks.

   b. ____________ are all employees involved in transportation industries including management and support people.

   c. Regulations are all state and federal regulatory agencies which issue the ____________ and enforce the ____________ and regulations of transportation industries.

Highways

Laws

Licenses

Personnel

Repair shops

Terminals

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

9. Identify technical subsystems. (Assignment Sheet #1)

10. Design a model racer. (Assignment Sheet #2)

11. Demonstrate the ability to build a model racer. (Job Sheet #1)

TRANSPORTATION TECHNICAL SUBSYSTEMS
UNIT VI

ANSWERS TO TEST

1. a. 5
   b. 3
   c. 6
   d. 1
   e. 4
   f. 2

2. a. 3
   b. 4
   c. 6
   d. 2
   e. 1
   f. 5

3. a. Sources
   b. Converters
   c. Mechanical
   d. Fluid
   e. Electrical

4. a. 3
   b. 1
   c. 2

5. a. Brakes
   b. Rudders
   c. Globe valves
   d. On-off

6. a. P
   b. O/E

7. a. Materials
   b. Methods
   c. Design considerations

8. a. Terminals, repair shops
   b. Personnel
   c. Licenses, laws

9.-10. Evaluated to the satisfaction of the instructor

11. Performance skills evaluated to the satisfaction of the instructor

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss types of pollution from various energy sources, list ways to control pollution and conserve energy, and construct a model maglev train. Competencies will be demonstrated by completing the assignment sheets, job sheet, and unit tests with a minimum of 85 percent.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms related to future projections and environmental impact of energy and transportation with the correct definitions.
2. Match types of pollution with the correct descriptions.
3. Complete statements concerning pollution from fossil fuels.
4. Match other energy sources with their correct pollutions and environmental impacts.
5. List ways to control pollution.
6. List energy conservation measures for areas of use.
7. Match emerging transmission systems with the correct descriptions.
8. Complete statements concerning advances in transportation.
9. Research trends in energy usage. (Assignment Sheet #1)

OBJECTIVE SHEET

10. Write a scenario of energy use in the year 2500. (Assignment Sheet #2)
11. Discuss the effect of a total absence of fossil fuels. (Assignment Sheet #3)
12. Demonstrate the ability to construct a model maglev train. (Job Sheet #1)

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACTS
UNIT VII

SUGGESTED ACTIVITIES

A. Obtain additional materials and/or invite resource people to class to supplement/reinforce information provided in this unit of instruction.

(NOTE: This activity should be completed prior to the teaching of this unit.)

B. Make transparencies from the transparency masters included in this unit.

C. Provide students with objective sheet.

D. Discuss unit and specific objectives.

E. Provide students with information and assignment sheets.

F. Discuss information and assignment sheets.

G. Provide students with job sheet.

H. Discuss and demonstrate the procedure outlined in the job sheet.

I. Integrate the following activities throughout the teaching of this unit:

   1. Do a low cost learning activity in Transportation Technology, "Technology Activities, Idea Book 1"; ITEA, Reston, VA; 1986; pp. 42-44.

   2. Discuss any environmental problems in your community and what can be done to prevent them in the future or lessen their effects.

   3. Contact state and national departments of energy and transportation for available materials on future projections and environmental impact of energy.

   4. Use local media to discuss trends affecting the environment.

   5. Discuss changes in cars to conserve energy and meet government regulations.

   6. Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

J. Give test.

K. Evaluate test.

L. Reteach if necessary.

REFERENCES USED IN DEVELOPING THIS UNIT

A. Berghauser, Thomas and Michael Kozak. *Systems of Technology: Laboratory Activities in Energy.* Austin, Texas: EIMC, 1986.

B. Bohn, Ralph C., et. al. *Energy, Power, and Transportation Technology.* Peoria, IL: Bennett & McKnight Publishing Co., 1986.

C. Hughes, Larry R. *Energy Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

D. Hughes, Larry R. and Alan L. Towler. *Transportation Systems.* Austin, Texas: Center for Occupational Curriculum Development Division of Continuing Education, The University of Texas at Austin, 1983.

E. Johnson, Jim. *Laser Technology: An Individual Learning Course.* Benton Harbor, Michigan: Heath Company, 1985.

F. *Principles of Technology: Energy.* Waco, Texas: Center for Occupational Research and Development, 1985.

G. Towler, Alan L. *Power Systems.* Austin, Texas: Center for Occupational Curriculum Development, 1983.

H. Wright, Thomas and Len Sterry, co-directors. *Industry and Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers.* Lansing, Illinois: Technical Foundation of America.

SUGGESTED SUPPLEMENTAL RESOURCES

Films:

A. The following films are available from:

Bureau of Audio Visual Instruction
P.O. Box 2093
Madison, WI 53701-2093
(608) 262-1644

1. *High Energy Efficiency — An Imperative for Tomorrow*; #02149; 25 min; Monumental, 1977
2. *Reserve for Tomorrow: A National Oil Reservoir*, #02245; 15 min; color; National AV Center, 1978
3. *River Town*; 28 min; color; Bullfrog, 1983
4. *Boeing vs. the World*; #11071; 30 min, 1982
5. *Working in Transportation*, 1982; #11151; 21 min.

SUGGESTED SUPPLEMENTAL RESOURCES

6. *The Robot Revolution,* 1985; #11058; 58 minutes

7. *Lasers: An Introduction,* 1970; #10555; 14 min.

B. *Reaching into Space,* 1980 (#04217, #04220)
Available from:
National Geographic Society
Washington, DC 20036

C. *Dynamics of Energy Efficiency,* 1980, 25 min., color
Available from:
Alliance to Save Energy
1925 K. Street, NW, Suite 507
Washington, D.C. 20006
202/857-0666

Pamphlets

A. *Saving Energy*
Motor Vehicle Manufacturers Association of the U.S., Inc.
300 New Center Building
Detroit, Michigan 48202

B. *Energy and Transportation*
U.S. Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, TN 37830

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

INFORMATION SHEET

I. **Terms and definitions**

A. Acid rain — Rain containing sulfuric acid resulting from a combination of water vapor and sulfur oxides released by fossil fuel combustion

B. Combustion — The chemical process of burning which releases heat, light, and chemical by-products

(NOTE: Each time a fuel is burned in a combustion process, some type of pollutant is released into the air.)

C. Conservation — Efficient use of energy with minimal waste

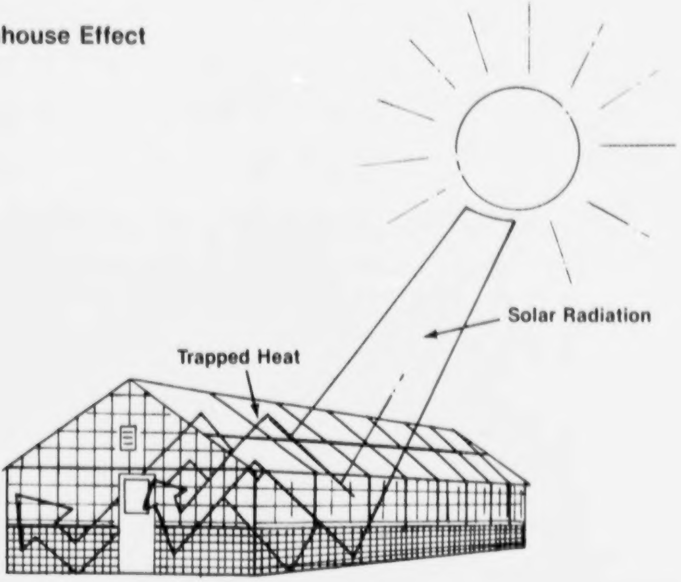
D. Cryogenics — Science dealing with the properties of materials at extremely low temperatures

E. Ecology — Science concerned with interrelationship between living organisms (plants, animals, humans) and their environments

F. Environment — The circumstances, objects, and conditions that surround an organism

G. Greenhouse effect — Warming of the earth's surface caused by solar radiation passing through the earth's atmosphere and then being trapped by air particles and water vapor so that the heat builds up like in a greenhouse

Greenhouse Effect



INFORMATION SHEET

H. Heavy metal poisoning — Contamination from primarily mercury and lead which are highly poisonous and can affect the human nervous system

I. Hydrocarbons — Organic compounds often occurring in petroleum, natural gas, coal, and bitumens

J. Jet lag — A disruption of body rhythms caused by high speed jet travel

K. Particulates — Tiny particles of solid or liquid matter

L. Pollutant — Something that contaminates the environment

M. Pollution — Any undesirable change in the air, land, or water that harmfully affects living things

N. Smog — Dense, brownish-yellow mass of air resulting from a combination of sunlight, hydrocarbons, and nitrogen oxides given off by automobile engines

O. Thermal inversion — Occurs when a layer of warm air settles over a layer of cooler air that lies near the ground; the warm air holds down the cool air and prevents pollutants from rising and scattering

II. **Types of pollution** (Transparency 1)

A. Air pollution — Comes from all combustion processes such as furnaces in factories and homes, vehicle engines, and the burning of trash and wood

B. Water pollution — Comes from industrial chemical wastes, runoff from fertilizers and pesticides, animal wastes, and human sewage

C. Land pollution — Comes from overuse of farm lands which exhaust the soils' nutrients, erosion from careless farming or land development, and solid wastes from human trash and litter

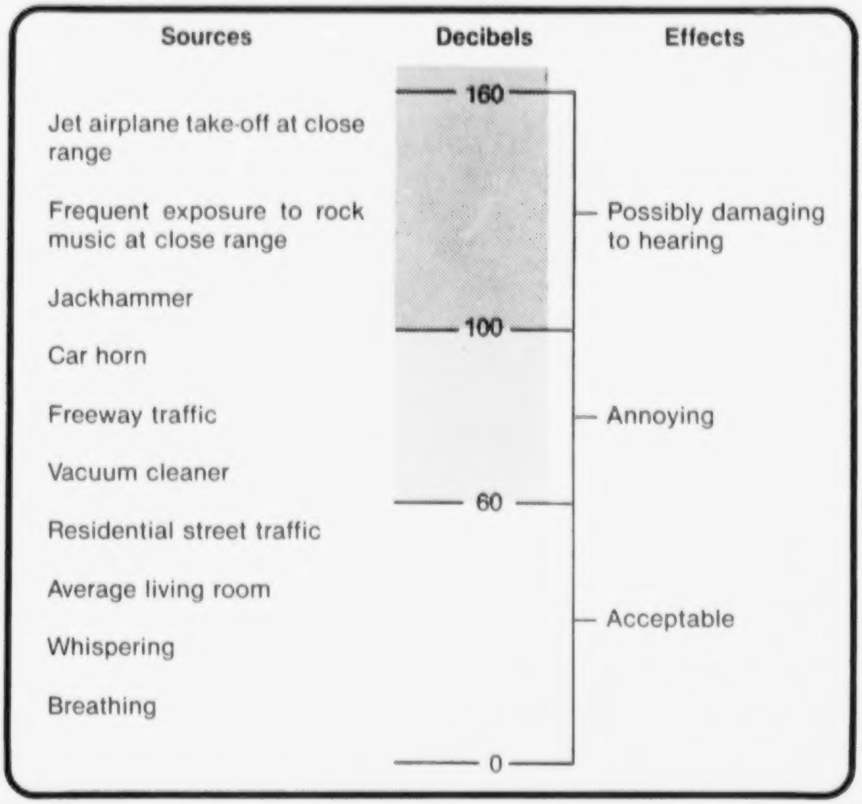
D. Other types of pollution

1. Radiation — Comes from sunlight, nuclear weapons and waste products, and some electronic devices; exposure to large amounts of radiation can cause cancer and death; scientists are studying the effects of smaller exposures

2. Thermal pollution — The addition of heated water to a body of water; this is primarily from industries and power plants and can kill animals and plants that are used to living at lower temperatures

INFORMATION SHEET

3. Noise pollution — Loud sounds such as from jet engines, jackhammers, and vehicle engines cause discomfort in people and can damage hearing



III. **Pollution from fossil fuels**

(NOTE: Most sources of controlled energy produce pollution although some sources of pollution are worse than others. Pollution from fossil fuels is among the worst.)

A. Air pollution (Transparency 2)

1. Smog

   a. Forms when sunlight hits the hydrocarbons and nitrogen oxides given off by automobile engines

   b. Makes breathing difficult, irritates eyes, and can injure lungs as well as damage plants

INFORMATION SHEET

2. Carbon monoxide
    a. Produced by automobile engines
    b. Reduces the oxygen-carrying capacity of the blood; causes headaches and dizziness and can be fatal in large amounts
3. Particulates — Dust, smoke, fumes, ash, and other materials such as lead particles given off by fossil fuel combustion
4. Earth warming — Fossil fuel combustion gives off excess carbon dioxide which warms the atmosphere.

    (NOTE: Too much warming of the earth could seriously change the present climates of the earth.)

B. Water pollution — Primarily acid rain

1. When coal and oil are burned, they release sulfur oxides into the air. When these sulfur oxides mix with water vapor in the air, the result is sulfuric acid. When it rains, the acid drops to earth.
2. It is very harmful to all forms of life. The most noticeable effects now are reduced fish populations.

C. Thermal pollution — Power plants release waste heat into rivers, lakes, and the oceans which changes the environments for the existing fish there. Many fish cannot survive these changes.

IV. Pollution and environmental impact from other sources of energy

A. Wood — Releases unburned chemical compounds and small burned particles (soot and other particles) which are harmful when inhaled

(NOTE: Wood is even more polluting than fossil fuels.)

B. Geothermal energy — Releases hydrogen sulfide gas into the air which results in acid rain

C. Hydroelectric energy — Produces no pollution but the damming of rivers changes natural biological systems such as animal habitats

D. Nuclear energy — Main pollution is the radioactive waste which must be handled with great care; nuclear accidents in nuclear plants can cause very severe pollution which can have long term effects on the environment

INFORMATION SHEET

V. **Ways to control pollution**

A. Develop more pollution-free energy sources.

B. Reduce pollution at source.

Examples: Emission-control devices on automobiles, filters added to power plant smoke stacks

C. Reduce use of energy through conservation.

(NOTE: Using less energy will create less pollution.)

VI. **Energy conservation measures for areas of use**

A. Home energy use

1. Use energy-efficient appliances.
2. Close up cracks around doors, windows, and foundations.
3. Provide adequate insulation in walls, ceilings, and foundations.
4. Reduce heating and cooling temperatures in home.
5. Develop energy-conservation habits.

   Examples: Turn off lights and appliances when not needed, use washing machine and dishwasher only when fully loaded, fix leaky faucets

6. Recycle materials. (Aluminum, glass, paper)

B. Business and industrial use

1. Close up cracks around doors, windows, and foundations.
2. Provide adequate insulation.
3. Reduce thermostats.
4. Improve efficiency of machines and processes used by industry.
5. Recover heat previously lost through smoke stacks and exhaust systems.
6. Recycle products and resources.
7. Stagger demand. Change usage so all people do not want it at the same time.

INFORMATION SHEET

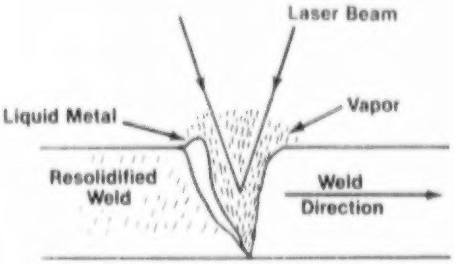
C. Transportation use

1. Carpool to work or school.
2. Plan trips using most direct and efficient routes.
3. Use modes of transportation other than personal automobile all the time. Use public transportation (mass transit) when possible. Walk and ride bicycles as much as possible.

4. Improve driving habits. Avoid sudden starts and stops.
5. Drive automobiles with smaller, more fuel-efficient engines.

VII. Emerging transmission systems

A. Lasers — Concentrated short electromagnetic wavelengths used in industry, medicine, and research for drilling, welding, cutting, and burning



B. Fiberoptics — Hair-thin strands of flexible glass used to carry communication messages

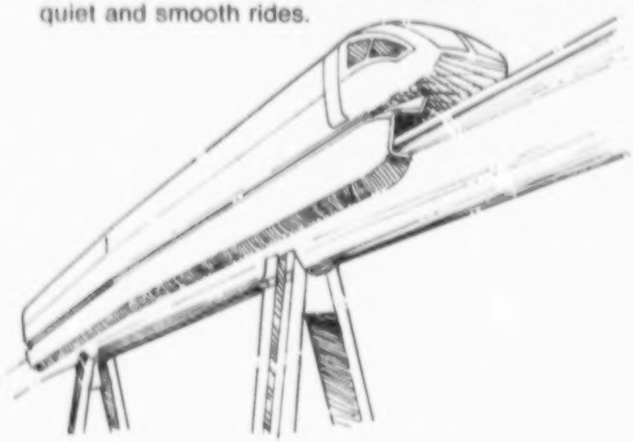
C. Cryogenics — Super cooling to prepare freeze-dried foods and to produce super-efficient generators and superconductors for more efficient transmission of electricity

INFORMATION SHEET

VIII. **Advances in transportation**

A. Rail transportation

1. Applying cryogenics to traditional rail transport, Maglev (magnetically levitated) trains can reach speeds of over 300 mph and provide quiet and smooth rides.



2. Computerized rail classification yards

3. Computerized people-moving systems (mass transit)

B. Highway transportation

1. Engines that burn methanol and synfuels

2. Engines that use hydrogen as a fuel

3. Electric vehicles powered by batteries

4. Electronic control systems

C. Air transportation

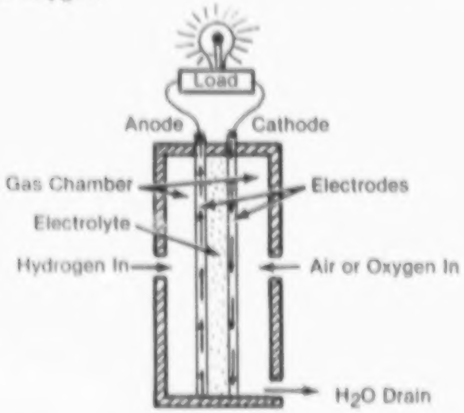
1. Propfan design

a. Has 8 to 10 shorter propeller blades that turn faster than regular blades.

b. Will use 20% less fuel.

INFORMATION SHEET

2. Canard design
   a. Wings are at or near the end of the aircraft.
   b. Are light, fast, fuel-efficient, and safe.
3. Fuel cells — Produce electricity from a chemical reaction between hydrogen and oxygen

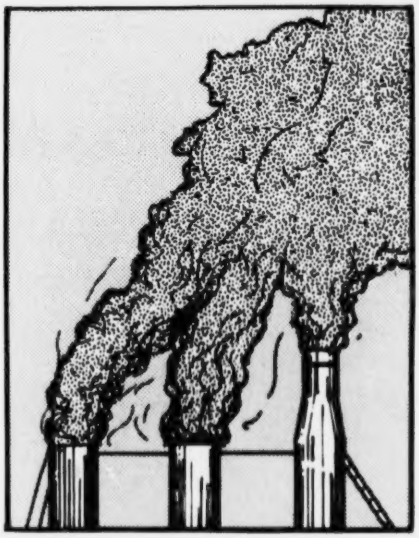

Load
Anode
Cathode
Gas Chamber
Electrodes
Electrolyte
Hydrogen In
Air or Oxygen In
H_2O Drain

(NOTE: The space shuttle *Columbia* used fuel cells to provide electrical power during flight.)

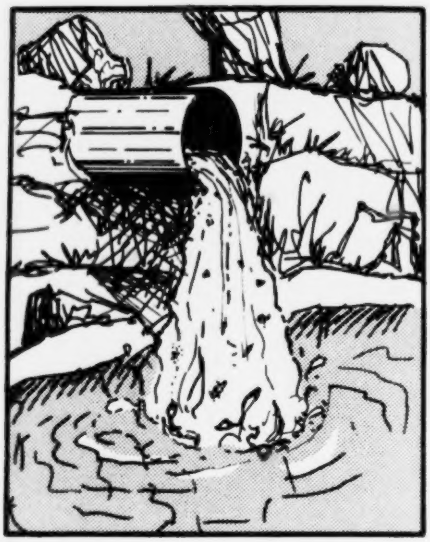
4. Composite materials -- New materials are being used such as hexel honeycomb, a resin-coated, paperlike polymer covered with graphite fibers imbedded in epoxy.

(NOTE: This was used in the construction of the *Voyager.*)

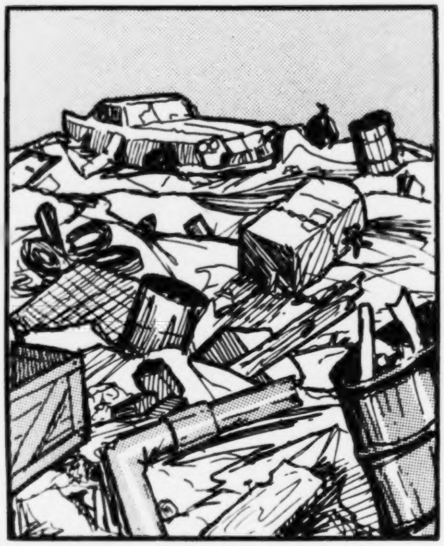
Types of Pollution



Air Pollution



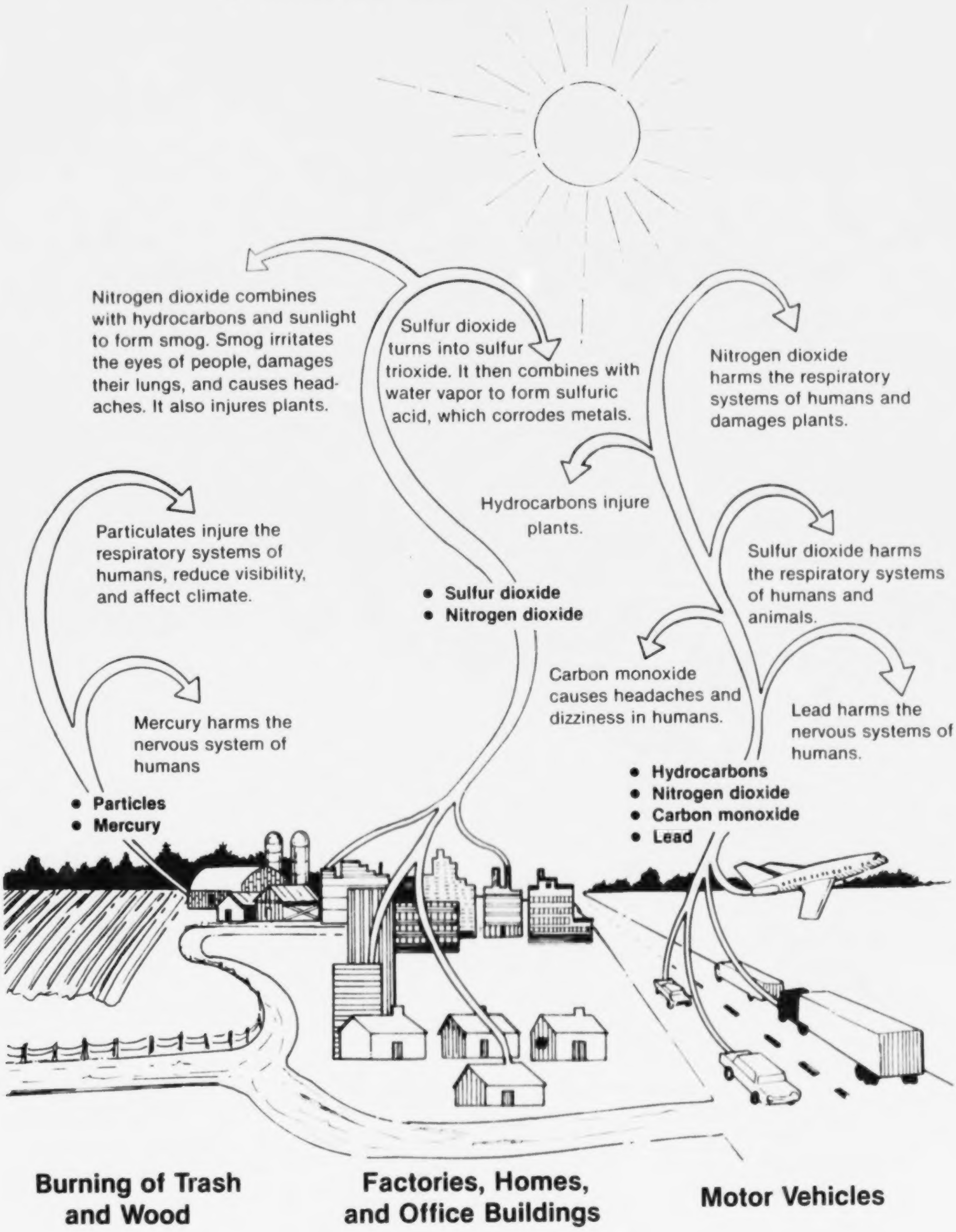
Water Pollution



Land Pollution

Air Pollution

(Pollutants and Their Effects)


Nitrogen dioxide combines with hydrocarbons and sunlight to form smog. Smog irritates the eyes of people, damages their lungs, and causes headaches. It also injures plants.
Sulfur dioxide turns into sulfur trioxide. It then combines with water vapor to form sulfuric acid, which corrodes metals.
Nitrogen dioxide harms the respiratory systems of humans and damages plants.
Hydrocarbons injure plants.
Particulates injure the respiratory systems of humans, reduce visibility, and affect climate.
• Sulfur dioxide
• Nitrogen dioxide
Sulfur dioxide harms the respiratory systems of humans and animals.
Carbon monoxide causes headaches and dizziness in humans.
Mercury harms the nervous system of humans
Lead harms the nervous systems of humans.
• Hydrocarbons
• Nitrogen dioxide
• Carbon monoxide
• Lead
• Particles
• Mercury
Burning of Trash and Wood
Factories, Homes, and Office Buildings
Motor Vehicles

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

ASSIGNMENT SHEET #1 — RESEARCH TRENDS IN ENERGY USAGE

NAME ______________________________ SCORE __________

Directions: Using a current scientific magazine as a source, research and discuss trends in energy usage for one source of energy (fossil fuels, nuclear energy, etc.).

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

ASSIGNMENT SHEET #2 — WRITE A SCENARIO OF ENERGY USE IN THE YEAR 2500

NAME ____ SCORE _____________

Directions: Using what we have covered in this unit and any outside resources, write a scenario of how you think energy will be used in the year 2500.

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

ASSIGNMENT SHEET #3 — DISCUSS THE EFFECT OF A TOTAL ABSENCE OF FOSSIL FUELS

NAME ______________________________ SCORE ____________

Directions: Using what we have covered in this unit and any outside resources, discuss what would happen if there were no fossil fuels left in the world. How would this change your life?

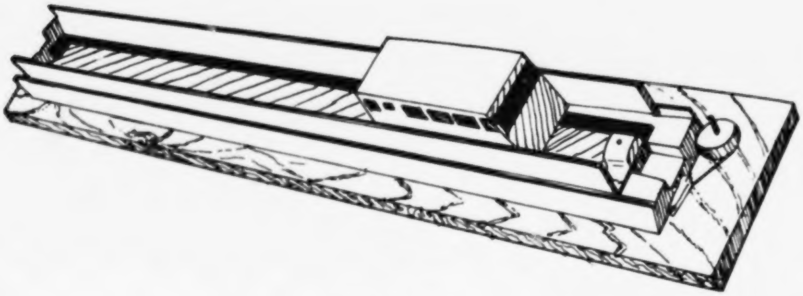
FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACTS
UNIT VII

JOB SHEET #1 — CONSTRUCT A MODEL MAGLEV TRAIN

A. Tools and materials

1. 1 - 3/4" × 6" × 36" wood
2. 1 - 1 1/2" × 3" × 30" aluminum channel
3. 1 - 3/4" × 3 1/2" × 32" wood
4. 2 - 5/8" × 1 1/4" × 32" wood
5. 2 - 3/4" × 1" × 1" wood
6. 1 - 6" × 16" ABS thin plastic or balsa wood
7. 2 - 1/2" × 3/4" × 2" bar magnets
8. 8 - .5 × .060" strip magnets, two poles on each side (12' divided into four 30" strips and four 6" strips)
9. 2 - 1" pulleys and axles
10. 1 - Fine nylon cord, 6' long (fishing line)
11. 1 - 1/2" × 2" spring
12. 1 - 1/8" welding rod, 6" long
13. Compass
14. Fasteners and adhesives
15. Tools as appropriate (Follow safety rules!)

FIGURE 1

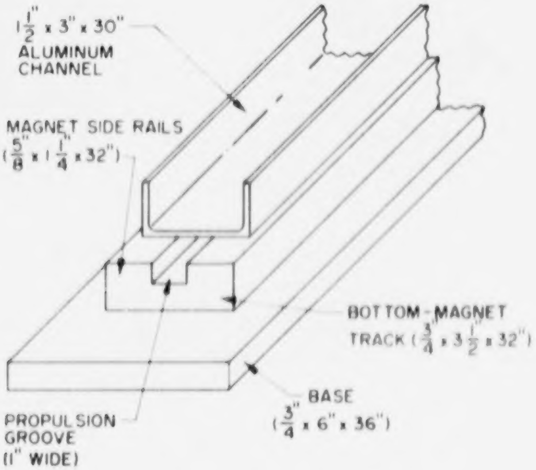


JOB SHEET #1

B. Procedure

1. Construct basic track assembly. End view is shown in Figure 2.

FIGURE 2


1 1/2" x 3" x 30"
ALUMINUM
CHANNEL
MAGNET SIDE RAILS
(5/8" x 1 1/4" x 32")
BOTTOM-MAGNET
TRACK (3/4" x 3 1/2" x 32")
BASE
(3/4" x 6" x 36")
PROPULSION
GROOVE
(1" WIDE)

a. Cut a ³/₄" × 6" × 36" base.

b. Cut a ³/₄" × 3¹/₂" × 32" bottom track to carry the propulsion magnet.

c. Center this on the base track and fasten.

d. Cut two ⁵/₈" × 1¹/₄" × 32" magnet side rails.

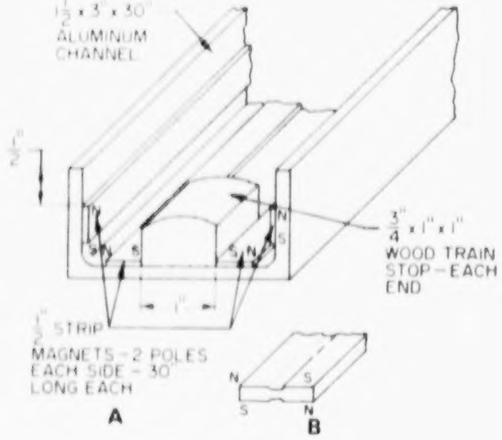
e. Position as shown and fasten, leaving a 1" groove for the propulsion magnet.

f. Center the 1¹/₂" × 3" × 30" aluminum channel on the side rails and fasten.

JOB SHEET #1

2. Examine Figure 3 making note of the locations of the strip magnets, their polarity, and the location of the train stops.

FIGURE 3


1½" x 3" x 30"
ALUMINUM
CHANNEL
½"
¾" x 1" x 1"
WOOD TRAIN
STOP—EACH
END
N
S
S
N
S
S
N
1"
½" STRIP
MAGNETS—2 POLES
EACH SIDE—30"
LONG EACH
A
N
S
S
N
B

   a. Cut strip magnets into 30" lengths.

      (NOTE: These can be cut with scissors.)

   b. Use a compass to determine the polarity of the magnets; the compass' north pole with point to the magnets' south pole.

   c. Mark magnets with chalk.

      (NOTE: Poles may also be identified by placing magnets next to each other; like poles repel each other.)

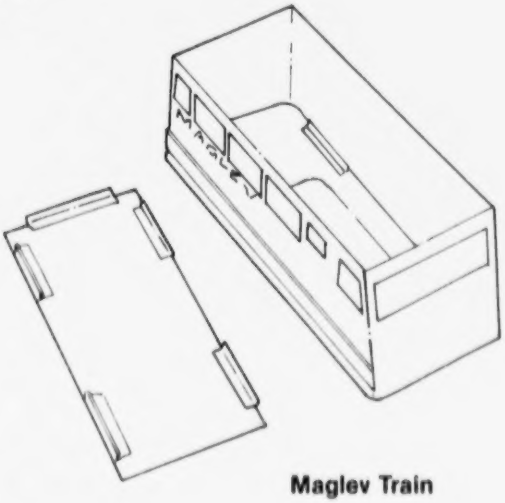
   d. Glue magnetic strips in the channel according to the measurements and polarity shown in Figure 3.

   e. Form and fasten wooden train stops to each end of the aluminum channel.

JOB SHEET #1

3. Build Maglev train as shown in Figures 4 and 5.

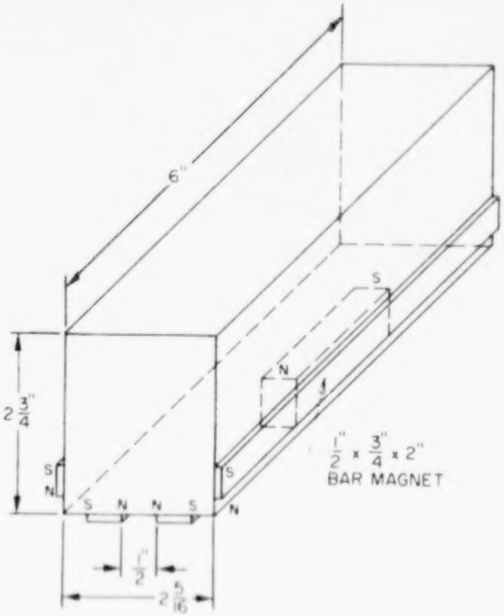
FIGURE 4



Maglev Train

a. Cut the plastic or balsa wood to the dimensions shown in Figure 5. The critical dimension is the train width.

FIGURE 5


6"
S
N
S
N
N
S
2 3/4"
S
N
S
N
1"/2
2 5/16
1/2" x 3/4" x 2"
BAR MAGNET

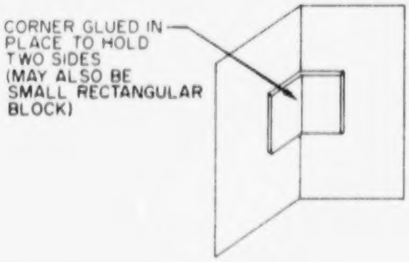
JOB SHEET #1

b. Cut the plastic or balsa wood to provide the minimum clearance between the magnets on the train and those on the channel.

c. Assemble the train using adhesive.

d. Add corner pieces of plastic or wood to strengthen the train as shown in Figure 6.

FIGURE 6


CORNER GLUED IN PLACE TO HOLD TWO SIDES (MAY ALSO BE SMALL RECTANGULAR BLOCK)

e. Do not glue the top. It should be removable.

f. Use the corner pieces as shown in Figure 4 to position the top.

g. Cut four magnet strips, 6" long.

h. Use a compass to determine the polarity.

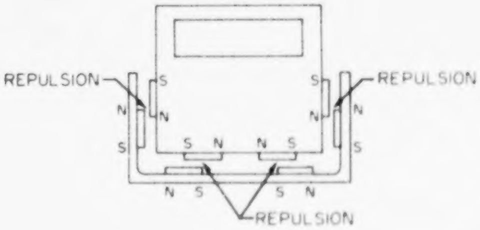
i. Glue magnets on the train positioning them as shown.

j. Glue a ½" × ¾" × 2" bar magnet in the train as shown in Figure 5.

4. Place the train in the track and check. It should be suspended in the air.

5. Check the polarity of the assembly as shown in Figure 7.

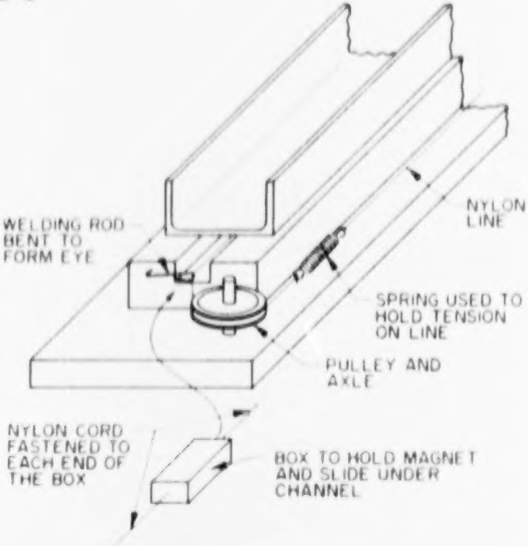
FIGURE 7


REPULSION
REPULSION
S
N
N
S
S
N
N
S
S N
N S
N S
S N
REPULSION

JOB SHEET #1

6. Assemble the propulsion system to the track. (Figure 8)

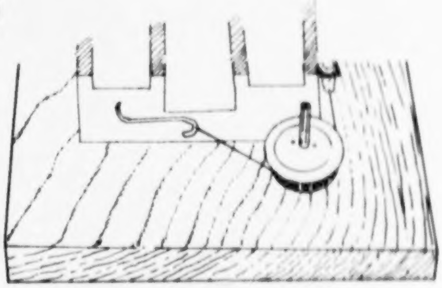
FIGURE 8


WELDING ROD BENT TO FORM EYE
NYLON LINE
SPRING USED TO HOLD TENSION ON LINE
PULLEY AND AXLE
NYLON CORD FASTENED TO EACH END OF THE BOX
BOX TO HOLD MAGNET AND SLIDE UNDER CHANNEL

a. Drill a hole at each end of the track.

b. Mount the pulleys so that the nylon cord can travel through and along side the propulsion groove. (Figure 9)

FIGURE 9



c. Assemble or find a small balsa wood or plastic box to hold the propulsion magnet. The box should just fit in the propulsion groove and hold the magnet.

d. Place the magnet in the box.

JOB SHEET #1

e. Drill small holes in each end of the box for attaching the nylon cord.

f. Cut the cord into two pieces, each 3′ long. Attach the pieces to the box, one on either end.

g. Place the box in the propulsion groove.

h. Position it so that the polarity is the same as that of the magnet in the train. The propulsion magnet must repel the train magnet to cause the train to move.

i. Run the cords in opposite directions through the eyes and around the pulleys (Figure 9).

j. Tie the cord ends to the ends of a spring which will maintain tension in the cord.

(NOTE: Another means of propelling this train is through the use of a rubber band and a plastic propeller.)

7. Test your train's propulsion by pulling the cord. As the propulsion magnet moves through the groove, it should repel the train magnet, causing the train to move down the track.

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FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACTS
UNIT VII

PRACTICAL TEST
JOB SHEET #1 — CONSTRUCT A MODEL MAGLEV TRAIN

STUDENT'S NAME ______________________________ DATE ____________

EVALUATOR'S NAME ______________________________ ATTEMPT NO. ______

Instructions: When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under "Process Evaluation" must receive a "Yes" for you to receive an overall performance evaluation.

PROCESS EVALUATION

(EVALUATOR NOTE: Place a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.)

The student:	YES	NO
1. Checked out proper tools and materials.	______	______
2. Constructed basic track assembly.	______	______
3. Cut strip magnets.	______	______
4. Determined magnet polarity.	______	______
5. Attached magnets to track assembly.	______	______
6. Built Maglev train.	______	______
7. Checked train and track for suspension.	______	______
8. Assembled propulsion system.	______	______
9. Tested train.	______	______
10. Checked in/put away tools and materials.	______	______
11. Cleaned the work area.	______	______
12. Used proper tools correctly.	______	______
13. Performed steps in a timely manner (___hrs. ___min. ___sec.)	______	______
14. Practiced safety rules throughout procedure.	______	______
15. Provided satisfactory responses to questions asked.	______	______

EVALUATOR'S COMMENTS: ____

____

PRACTICAL TEST

PRODUCT EVALUATION

(**EVALUATOR NOTE**: Rate the student on the following criteria by circling the appropriate numbers. Each item must be rated at least a "3" for mastery to be demonstrated. (See performance evaluation key below.) If the student is unable to demonstrate mastery, student materials should be reviewed and another product must be submitted for evaluation.)

Criteria:

	4	3	2	1
Basic Track Assembly	Channel Centered Groove Correct Base OK	Aluminum Channel Too Long	Aluminum Channel Not Centered	Propulsion Groove Too Narrow/ Too Wide
	4	3	2	1
Magnetic Suspension System	Polarity Correct/ Strips Correct Length	Reverse Magnet Polarity	Magnet Strips Too Long	Magnet Strips Too Short
	4	3	2	1
Maglev Train	Clearance Meets Minimum Specifications	Body Needs Reinforcement	Reposition Magnets/ Wrong Polarity	Clearance Exceeds Maximum Specifications
	4	3	2	1
Propulsion System	Clearance Meets Minimum Specifications	Cord Too Long Not Enough Tension	Cord Too Short, Too Much Tension	Propulsion Box Too Wide/ Too Narrow

EVALUATOR'S COMMENTS: ______________________________

____

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

(**EVALUATOR NOTE**: If an average score is needed to coincide with a competency profile, total the designated points in "Product Evaluation" and divide by the total number of criteria.)

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

NAME ______________________________ SCORE ________________________

TEST

1. Match the terms on the right with the correct definitions.

______a. Dense, brownish-yellow mass of air resulting from a combination of sunlight, hydrocarbons, and nitrogen oxides given off by automobile engines

______b. The circumstances, objects, and conditions that surround an organism

______c. Something that contaminates the environment

______d. Efficient use of energy with minimal waste

______e. Science concerned with interrelationship between living organisms (plants, animals, humans) and their environments

______f. Rain containing sulfuric acid resulting from a combination of water vapor and sulfur oxides released by fossil fuel combustion

______g. Tiny particles of solid or liquid matter

______h. Science dealing with the properties of materials at extremely low temperatures

______i. Occurs when a layer of warm air settles over a layer of cooler air that lies near the ground; the warm air holds down the cool air and prevents pollutants from rising and scattering

______j. Contamination from primarily mercury and lead which are highly poisonous and can affect the human nervous system

______k. Warming of the earth's surface caused by solar radiation passing through the earth's atmosphere and then being trapped by air particles and water vapor so that the heat builds up

1. Acid rain
2. Combustion
3. Conservation
4. Cryogenics
5. Ecology
6. Environment
7. Greenhouse effect
8. Heavy metal poisoning
9. Hydrocarbon
10. Particulates
11. Pollutant
12. Radiation
13. Smog
14. Thermal inversion

TEST

_____l. The chemical process of burning which releases heat, light, and chemical by-products

_____m. Organic compounds often occurring in petroleum, natural gas, coal, and bitumens

2. Match types of pollution on the right with the correct descriptions.

_____a. Loud sounds such as from jet engines, jackhammers, and vehicle engines cause discomfort in people and can damage hearing

_____b. The addition of heated water to a body of water; this is primarily from industries and power plants and can kill animals and plants that are used to living at lower temperatures

_____c. Comes from industrial chemical wastes, runoff from fertilizers and pesticides, animals wastes, and human sewage

_____d. Comes from all combustion processes such as furnaces in factories and homes, vehicle engines, and the burning of trash and wood

_____e. Comes from overuse of farm lands which exhaust the soils' nutrients, erosion from careless farming or land development, and solid wastes from human trash and litter

_____f. Comes from sunlight, nuclear weapons and waste products, and some electronic devices; exposure to large amounts of it can cause cancer and death

1. Air pollution
2. Land pollution
3. Noise pollution
4. Radiation
5. Thermal pollution
6. Water pollution

3. Complete statements concerning pollution from fossil fuels by circling the correct words.

a. Smog makes (**thinking, breathing**) difficult, irritates eyes, and can injure (**heart, lungs**) as well as damage plants.

b. Carbon monoxide (**can, can not**) be fatal in large amounts.

c. Carbon monoxide exposure causes (**headaches, stomachaches**).

d. Fossil fuel combustion gives off excess (**sulfur dioxide, carbon dioxide**) which warms the atmosphere.

TEST

e. Acid rain is (**slightly, very**) harmful to all forms of life.

f. The most noticeable effects of acid rain are reduced (**fish, human**) populations.

4. Match other energy sources on the right with the correct pollutions and environmental impacts.

_____a. Releases unburned chemical compounds and small burned particles (soot and other particles) which are harmful when inhaled

_____b. Releases hydrogen sulfide gas into the air which results in acid rain

_____c. Produces no pollution but the damming of rivers changes natural biological systems such as animal habitats

_____d. Main pollution is the radioactive waste which must be handled with great care; accidents can cause very severe pollution which can have long term effects on the environment

1. Geothermal energy
2. Wood
3. Nuclear energy
4. Hydroelectric energy

5. List two ways to control pollution.

a. ______________________________

b. ______________________________

6. List three energy conservation measures for each of the following areas:

a. Home energy use

1) ______________________________

2) ______________________________

3) ______________________________

b. Business and industrial use

1) ______________________________

2) ______________________________

3) ______________________________

TEST

c. Transportation use

1) ____________________

2) ____________________

3) ____________________

7. Match emerging transmission systems on the right with their correct descriptions.

_____a. Concentrated short electromagetic wavelengths used in industry, medicine, and research for drilling, welding, cutting, and burning

_____b. Hair-thin strands of flexible glass used to carry communication messages

_____c. Super coding to prepare freeze-dried foods and to produce super-efficient generators and superconductors for more efficient transmission of electricity

1. Cryogenics
2. Fiber optics
3. Lasers
4. Robots

8. Complete the following statements concerning advances in transportation by circling the correct words.

a. An advancement in air transportation is the propfan design which has 8 to 10 shorter propeller blades that turn (**slower, faster**) than regular blades and will use (**20%, 80%**) less fuel.

b. The (**Canary, Canard**) design has wings at or near the end of the aircraft. This design is light, fast, fuel-efficient, and safe.

c. Applying (**cybernetics, cryogenics**) to traditional rail transport, Maglev trains can reach speeds of over 300 mph and provide quiet and smooth rides.

d. An advancement in highway transportation is engines that burn (**methanol, ethanol**), synfuels, and (**hydrogen, oxygen**).

e. An advancement in space transportation is the use of (**battery, fuel**) cells which produce electricity from a chemical reaction between hydrogen and oxygen.

(NOTE: If the following activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

9. Research trends in energy usage. (Assignment Sheet #1)

10. Write a scenario of energy use in the year 2500. (Assignment Sheet #2)

11. Discuss the effect of a total absence of fossil fuels. (Assignment Sheet #3)

12. Demonstrate the ability to construct a model maglev train. (Job Sheet #1)

FUTURE PROJECTIONS AND ENVIRONMENTAL IMPACT
UNIT VII

ANSWERS TO TEST

1. a. 13
   b. 6
   c. 11
   d. 3
   e. 5
   f. 1
   g. 10
   h. 4
   i. 14
   j. 8
   k. 7
   l. 2
   m. 9

2. a. 3
   b. 5
   c. 6
   d. 1
   e. 2
   f. 4

3. a. Breathing, lungs
   b. Can
   c. Headaches
   d. Carbon dioxide
   e. Very
   f. Fish

4. a. 2
   b. 1
   c. 4
   d. 3

5. Any two of the following:
   a. Develop more pollution-free energy sources.
   b. Reduce pollution at source.
   c. Reduce use of energy through conservation.

6. Any three from each of the following:
   a. Home energy use
      1) Use energy-efficient appliances.
      2) Close up cracks around doors, windows, and foundations.
      3) Provide adequate insulation in walls, ceilings, and foundations.
      4) Reduce heating and cooling temperatures in home.
      5) Develop energy-conservation habits.
      6) Recycle materials. (Aluminum, glass, paper)
   b. Business and industrial use
      1) Close up cracks around doors, windows, and foundations.
      2) Provide adequate insulation.
      3) Reduce thermostats.
      4) Improve efficiency of machines and processes used by industry.
      5) Recover heat previously lost through smoke stacks and exhaust systems.
      6) Recycle products and resources.
      7) Stagger demand.

ANSWERS TO TEST

c. Transportation use
   1) Carpool to work or school.
   2) Plan trips using most direct and efficient routes.
   3) Use modes of transportation other than personal automobile all the time. Use public transportation when possible. Walk and ride bicycles as much as possible.
   4) Improve driving habits. Avoid sudden starts and stops.
   5) Drive automobiles with smaller, more fuel-efficient engines.

7. a. 3
   b. 2
   c. 1

8. a. Faster, 20%
   b. Canard
   c. Cryogenics
   d. Methanol, hydrogen
   e. Fuel

9.-11. Evaluated to the satisfaction of the instructor

12. Performance skills evaluated to the satisfaction of the instructor